# Air Quality Monitoring

## Whitecourt Area

September 6th and 7th, 2005 — Final Report

### *Introduction*

In 2005, Alberta Environment received odour complaints associated with mechanical pulp mill sludge, land spreading activities on agricultural land east of Whitecourt, Alberta. In order to make an accurate assessment of air quality in the areas where pulp mill sludge was being spread, it was necessary to coordinate the air quality survey at the time, the sludge was being applied and land spread onto agricultural land. Alberta Environment conducted the air survey on September 6th and 7th 2005. The data collected during this air quality survey are presented in this report.

The survey in the Whitecourt area consisted of two components: The department's Mobile Air Monitoring Laboratory (**MAML**) and canister samples of air for later analysis of a suite volatile organic compounds (**VOCs**). The MAML provides a "snapshot" in time and space of ***the air quality*** at the monitoring location. Pollutants measured by the MAML include ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, reduced sulphur compounds and sulphur dioxide. A detailed description of the MAML is given in Appendix B.

The objectives of air quality monitoring in this area were: (1) To identify and determine the concentrations of air pollutants near pulp mill sludge spreading areas, (2) compare air quality at the sample locations with Alberta Ambient Air Quality Objectives (**AAAQO**) and other monitoring location in Alberta, and (3) to address odour complaints by comparing measured pollutants to odour thresholds when available. A description of AAAQO is found in Appendix B.

The MAML monitored the air quality at three locations: Two of the sites were near fields with sludge loading and spreading operations and a third was downwind of spreading operations. Each location was monitored for a minimum of one hour. To facilitate comparison with applicable one-hour AAAQO and other air quality data, median one-hour average concentrations are reported. Results from other mobile surveys and 2005 data from permanent monitoring stations in Alberta are also presented for comparison.

Alberta
ENVIRONMENT

Canister samples of air for VOCs analysis were taken at five locations. Three of the samples were collected along side the MAML monitoring. In addition, one background sample and one upwind sample were also collected.

The FIDOL factors (frequency, intensity, duration, offensiveness, and location) help determine if an odour is objectionable. To evaluate ***short-term elevations*** in air pollutant concentrations, maximum concentrations using one-minute average data are reported. Where available these one-minute values are compared to odour thresholds. It is important to note that perceived odour levels can vary between individuals; and individuals may perceive odours at concentrations well below levels that may have adverse health effects. Odourous pollutants measured by the MAML include ammonia and hydrogen sulphide. In addition a number of the VOCs sampled in the canisters are known to have an odour.

ISBN No. 978-0-7785-5460-8 (Printed Edition)
ISBN No. 978-0-7785-5461-5 (On-Line Edition)
**January 12, 2007**

# *Overview*

**(1) Odorous pollutants measured by the MAML: ammonia and hydrogen sulphide.**

a. Ammonia concentrations measured at all locations were below AAAQO and odour thresholds[1]. Elevated levels of ammonia were measured only at one of two locations near sludge spreading operations. The maximum (one-minute average) ammonia concentration measured was 1.203 ppm (parts per million). This short-term increase was 60% of the one-hour AAAQO and 24% of odour threshold.

b. One-hour average hydrogen sulphide concentrations at all the monitoring locations were lower than AAAQO and odour thresholds[2]. However, short-term elevated concentrations equal to and higher than odour threshold were measured close to fields with sludge spreading operations. Maximum hydrogen sulphide concentrations measured near the two sludge spread fields were 0.024 and 0.008 ppm.

c. Concentrations of both ammonia and hydrogen sulphide were notably lower 2 km downwind from sludge spreading area. The maximum ammonia concentration measured at this location was 0.015 ppm. The maximum hydrogen sulphide concentration was 0.001 ppm.

**(2) Other elevated pollutants**

a. Other pollutants measured by the MAML that were prominent close to sludge spreading operations include, hydrocarbons and particulate matter.

b. Maximum total hydrocarbon concentrations of 6.6 and 3.7 ppm were measured at the two sites close to sludge spreading operations. At the downwind site a maximum concentration of 2.5 ppm was measured.

c. One-hour average particle PAH concentrations were low or below the detection; however elevated short-term concentrations of 111 and 11 ng/$m^3$ (nanograms per cubic meter of air) were measured close to pulp mill sludge spreading operations. All PAH concentrations at the downwind site were below the detection.

d. Maximum $PM_{10}$ concentrations measured at the two sites near sludge spreading operations were 924 and 1222 µg/$m^3$ (micrograms per cubic meter of air). Maximum $PM_{2.5}$ concentrations at the same site were 47 and 57 µg/$m^3$. Comparatively, maximum $PM_{10}$ and $PM_{2.5}$ concentrations at the downwind site were 34 and 3 µg/$m^3$, respectively.

e. Elevated hydrocarbons and particulate concentrations close to sludge spreading operations were most probably due to re-suspended soil particles and nearby vehicle emissions, such as spreading trucks.

---

1 - Agency for toxic substances and disease registry: Medical management for ammonia. Retrieved November 14,2006 from http://www.atsdr.cdc.gov/MHMI/mmg126.html

2 - World Heath Organization (WHO). Concise International chemical assessment document 53. Retrieved November 14, 2006 from http://www.inchem.org/documents/cicads/cicads/cicad53.htm

**(3) Volatile Organic Compounds**

a. Analysis of canister samples indicated that VOCs concentrations near sludge spreading areas were low. Only a small fraction of VOCs, 18 of the over 109 compounds analyzed, were above the detection limit.

b. Concentrations measured near sludge spreading operations were for the most part comparable to or lower than concentrations measured at the background and upwind locations. The exception was toluene, which was elevated close to sludge spreading activities. Concentrations at the two sites were 2.63 and 0.56 $\mu g/m^3$. Background concentration of toluene in the area was 0.11 $\mu g/m^3$. Motor vehicle emissions and evaporation loss are the main sources of ambient toluene concentrations. Elevated levels near sludge spreading operations may be due to nearby vehicles emissions. However, evaporation losses from pulp mill sludge cannot be excluded as a source. Nevertheless, these concentrations of toluene were significantly lower than AAAQO (1880 $\mu g/m^3$) and odour threshold (8025 $\mu g/m^3$).

c. Acetaldehyde concentrations (2.6 $\mu g/m^3$) measured 2 km downwind of sludge spreading operations was the only VOC above the odour threshold. This elevated concentration are likely not be associated with pulp mill sludge spreading, as concentrations near spreading operations were either significantly lower or not detected.

**(4) Odour threshold**

a. MAML monitoring and VOCs analysis indicate that the pollutants measured near pulp mill sludge spreading operations were below odour threshold individually; with the exception of hydrogen sulphide. Odour complaints at these locations maybe due to a combination of compounds that may be present at low concentrations. As many as 168 compounds have previously been associated with a single odour[1]. Furthermore, odours that may be below odour threshold individually may interact such that there is an enhancement of the mixture[2].

1 - O'Neil, D.H. and V.R.A. Phillips, 1992. Review of the control of odour nuisance from livestock buildings: Part 3 Properties of the odourous substances which have been identified in livestock wastes or in the air around them. Journal of Agricultural Engineering Research, 53: 23-50.

2 - Laska M. and R. Hudson, 1991. A comparison of the detection thresholds of odour mixtures and their components. Chemical senses, 16: 651- 662.

**Table 1: Summary of MAML Monitoring results for the Whitecourt Survey.**

| Pollutant | Units | AAAQO | Minimum* | Median* | Maximum* |
|---|---|---|---|---|---|
| **Hydrocarbons** | | | | | |
| Methane ($CH_4$) | ppm | n/a | 2.0 | 2.1 | 6.1 |
| Reactive hydrocarbon (RHC) | ppm | n/a | bd | bd | 0.3 |
| Total Hydrocarbons (THC) | ppm | n/a | 2.0 | 2.1 | 6.6* |
| Polycyclic Aromatic Hydrocarbon (PAH) | $ng/m^3$ | n/a | bd | 1.0 | 111 |
| **Sulphur Compounds** | | | | | |
| Hydrogen Sulphide ($H_2S$) | ppm | 0.01[a] | bd | 0.001 | 0.024 |
| Total Reduced Sulphur (TRS) | ppm | n/a | bd | 0.001 | 0.009* |
| Sulphur Dioxide ($SO_2$) | ppm | 0.172[b] | bd | 0.001 | 0.015 |
| **Particles** | | | | | |
| Respirable particle matter (<2.5 µm) | $\mu g/m^3$ | n/a | 1 | 2 | 57 |
| Inhalable particle matter (<10 µm) | $\mu g/m^3$ | n/a | 7 | 16 | 1222 |
| Total suspended Particles | $\mu g/m^3$ | n/a | 10 | 28 | 2356 |
| **Other pollutants** | | | | | |
| Ammonia ($NH_3$) | ppm | 2[a] | 0.001 | 0.084 | 1.203 |
| Carbon monoxide (CO) | ppm | 13[c] | bd | 0.2 | 1.8 |
| Ozone ($O_3$) | ppm | 0.082[d] | 0.003 | 0.027 | 0.037 |
| Nitrogen Oxide (NO) | ppm | n/a | 0.001 | 0.003 | 0.158 |
| Nitrogen Dioxide ($NO_2$) | ppm | 0.212[a] | bd | 0.002 | 0.071 |
| Oxides of Nitrogen ($NO_x$) | ppm | n/a | 0.001 | 0.005 | 0.172 |

*** Minimum and median values were calculated using one-hour average data. Maximum concentrations indicate the peak measured concentrations, these are based on one-minute average data.**

ppm – parts per million  $ng/m^3$ – nanograms per cubic meter of air  $\mu g/m^3$ – micrograms per cubic metre of air

AAAQO – one-hour Alberta Ambient Air Quality Objective  n/a – no one-hour objective  bd – below detection limit

a – objective based on odour perception  b – objective based on pulmonary function

c – objective based on oxygen carrying capacity of blood

d - objective based on reduction of lung function and effect on vegetation

* The method of measurement for THC and TRS is pseudo-continuous; that is the instrument measures different compounds within a family of compounds in series. The cycle of measurements is perfumed in under a minute. Thus, when calculating short-term concentrations, THC may not be equivalent to $CH_4$ + RHC, similarly TRS may be less than $H_2S$.

**Table 1: Summary of MAML Monitoring results for the Whitecourt Survey.**

| Pollutant | Units | AAAQO | Minimum* | Median* | Maximum* |
|---|---|---|---|---|---|
| **Hydrocarbons** | | | | | |
| Methane **($CH_4$)** | ppm | n/a | 2.0 | 2.1 | 6.1 |
| Reactive hydrocarbon **(RHC)** | ppm | n/a | bd | bd | 0.3 |
| Total Hydrocarbons **(THC)** | ppm | n/a | 2.0 | 2.1 | 6.6* |
| Polycyclic Aromatic Hydrocarbon **(PAH)** | $ng/m^3$ | n/a | bd | 1.0 | 111 |
| **Sulphur Compounds** | | | | | |
| Hydrogen Sulphide **(H2S)** | ppm | 0.01[a] | bd | 0.001 | 0.024 |
| Total Reduced Sulphur **(TRS)** | ppm | n/a | bd | 0.001 | 0.009* |
| Sulphur Dioxide **($SO_2$)** | ppm | 0.172[b] | bd | 0.001 | 0.015 |
| **Particles** | | | | | |
| Respirable particle matter (<2.5 μm) | $\mu g/m^3$ | n/a | 1 | 2 | 57 |
| Inhalable particle matter (<10 μm) | $\mu g/m^3$ | n/a | 7 | 16 | 1222 |
| Total suspended Particles | $\mu g/m^3$ | n/a | 10 | 28 | 2356 |
| **Other pollutants** | | | | | |
| Ammonia **($NH_3$)** | ppm | 2[a] | 0.001 | 0.084 | 1.203 |
| Carbon monoxide **(CO)** | ppm | 13[c] | bd | 0.2 | 1.8 |
| Ozone **($O_3$)** | ppm | 0.082[d] | 0.003 | 0.027 | 0.037 |
| Nitrogen Oxide **(NO)** | ppm | n/a | 0.001 | 0.003 | 0.158 |
| Nitrogen Dioxide **($NO_2$)** | ppm | 0.212[a] | bd | 0.002 | 0.071 |
| Oxides of Nitrogen **($NO_x$)** | ppm | n/a | 0.001 | 0.005 | 0.172 |

*** Minimum and median values were calculated using one-hour average data. Maximum concentrations indicate the peak measured concentrations, these are based on one-minute average data.**

ppm = parts per million ng/m³ = nanograms per cubic meter of air μg/m³ = micrograms per cubic metre of air

AAAQO = one-hour Alberta Ambient Air Quality Objective n/a = no one-hour objective bd = below detection limit

a = objective based on odour perception b = objective based on pulmonary function

c = objective based on oxygen carrying capacity of blood

d = objective based on reduction of lung function and effect on vegetation

* The method of measurement for THC and TRS is pseudo-continuous, that is the instrument measures different compounds within a family of compounds in series. The cycle of measurements is performed in under a minute. Thus, when calculating short-term concentrations, THC may not be equivalent to $CH_4$ + RHC, similarly TRS may be less than $H_2S$.

# *Monitoring Method and Locations*

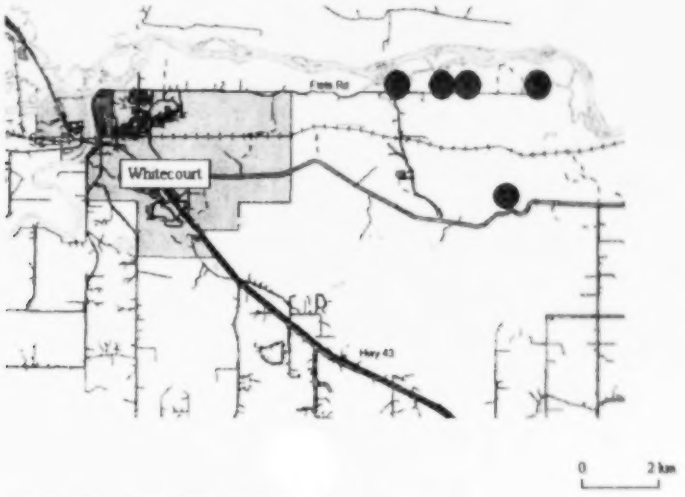
The air quality near and downwind of fields with active pulp and paper sludge spreading was monitored using Alberta Environment's mobile laboratory, MAML. In addition, air samples were collected using canisters for VOCs analysis. In addition to the co-located canister and MAML samples two additional canister samples were taken; these were an upwind sample and a background sample. Monitoring locations and time of year were selected based on public complaints and consultation with Alberta Environment's Compliance and Industrial Approval staff.

The MAML monitored ambient air quality at the following three locations:

- **Access Road** to sludge spreading area (September 6th), (MAML site #1)
- 2 km **Downwind** of loading and spreading area (September 6th) (MAML site #2), and
- **Flats Road** near new sludge spreading area (September 7th) (MAML site #3).

Hereafter these monitoring sites will be referred to as **Access road**, **downwind** and **Flats Road**. The locations for the MAML and canister sample sites are presented in Figure 1. The two monitoring locations at the sludge spreading site provide information on the maximum ambient concentrations associated with sludge spreading operations. Concentrations at the downwind site indicate the scope of pollutants associated sludge spreading operations. The background and upwind site are used to establish background concentrations in the area.

Monitoring was conducted for a minimum of one-hour to allow comparison to AAAQO and other air quality monitoring data. Air samples for VOC analysis were collected for an hour, such that concentrations determined were an average for that hour. Figures 2 depict the MAML monitoring locations.




A- **Access Road** MAML site #1, VOC sample #4
B- **Downwind** MAML site #2, VOC sample #5
C- **Flats Road** MAML site #3, VOC sample #3
D- **Background** VOCs sample #1
E- **Upwind** VOCs sample #2

**Figure 1: Locations monitored by the MAML and canister samples in the Whitecourt Area.**

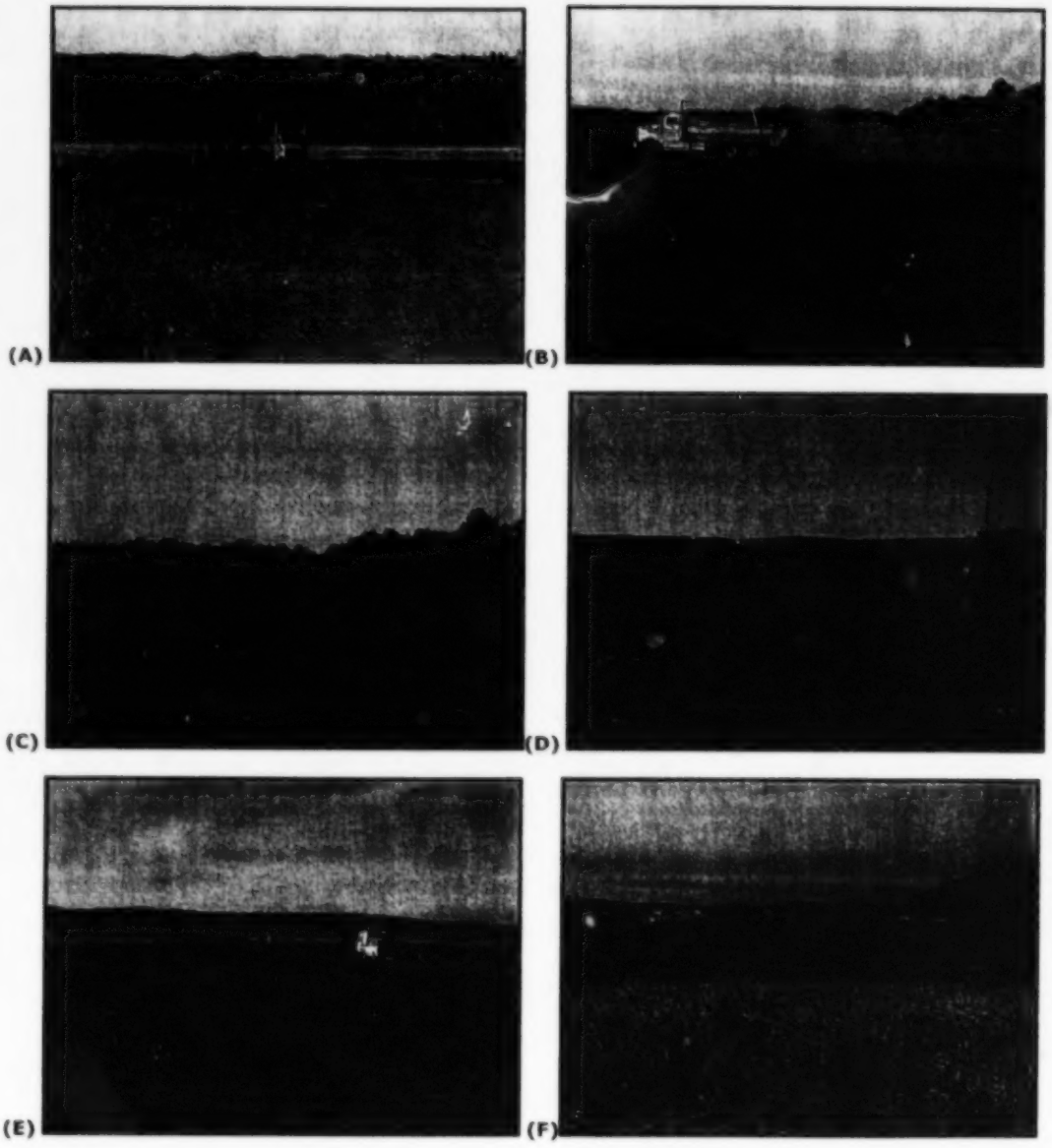



**Figure 2: Photographs depicting the MAML monitoring locations and nearby sludge spreading operations. (A) Illustrates loading of sludge onto spreading truck and sludge spreading operations is shown in (B). Photograph B also shows steam rising from the sludge being spread. (C) and (D) depict southerly and westerly view from the Access Road site, respectively. In both photographs, sludge spreading trucks can be seen in the background. (E) and (F) show southerly and westerly views from the Flats Road site, spreading operations can be seen in the background.**

# *Results Discussion*

The median concentration is a common way of representing the central value for environmental data. Most environmental data usually consist of a distribution that is skewed to the right; that is most data values are low and only a few are high. For such data sets arithmetic mean will be biased by the high concentrations; the resulting value may not be representative of the central value for the data set. For example, a data distribution consisting of five numbers: 1, 2, 2, 3 and 10. The arithmetic mean of these data is 3.6 and the median is 2. In this case, the arithmetic mean is biased high by the extreme value of 10. The median is the middlemost value in the data set; thus more representative of the central value of the data distribution. Fifty percent of the values in the dataset are below the median and fifty percent are above. In this report, the median value of one-hour average concentrations is used as middlemost value of the data collected at a monitoring location. This value indicates the general overall concentration at a site. Hereafter, this value will be referred to as the ***median one-hour concentration***.

Many areas in Alberta are pristine and certain pollutants that Alberta Environment monitors for are found in concentrations below the lower detection limit of the instruments onboard the MAML. A dataset may contain a large number of concentrations below the detection limit and few concentrations within the operating range of the MAML instruments. With this data set, it is possible to have an overall median concentration that is 'undetectable' or below the lower detection limit (***bd***) while still having a short-term 'detectable' maximum value. Unlike the median one-hour concentration, maximum concentrations reported are determined using data collected at one-minute intervals. The maximum concentrations presented in this report indicate the peak value measured at the monitoring location. The median one-hour and maximum detectable values for air pollutants measured will be presented as illustrated in Figure 3. Figures 4 through 13 provide the median one-hour average and maximum concentrations for parameters of relevant to the survey.

The MAML is equipped to measure a number of air pollutants. Concentrations of all the pollutants measured during this survey are presented in Appendix A. The discussions in the result section will focus on the pollutants that are relevant to the current survey.

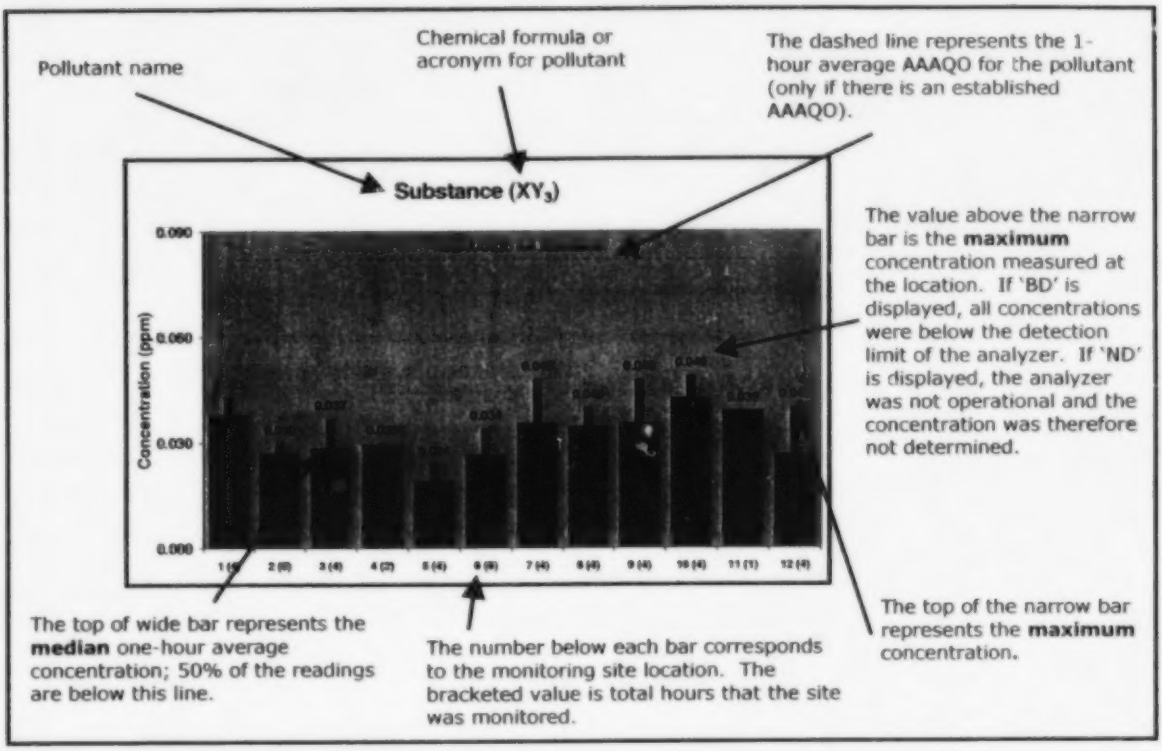

Pollutant name
Chemical formula or acronym for pollutant
The dashed line represents the 1-hour average AAAQO for the pollutant (only if there is an established AAAQO).
Substance ($XY_3$)
Concentration (ppm)
0.090
0.060
0.030
0.000
The value above the narrow bar is the **maximum** concentration measured at the location. If 'BD' is displayed, all concentrations were below the detection limit of the analyzer. If 'ND' is displayed, the analyzer was not operational and the concentration was therefore not determined.
The top of wide bar represents the **median** one-hour average concentration; 50% of the readings are below this line.
The number below each bar corresponds to the monitoring site location. The bracketed value is total hours that the site was monitored.
The top of the narrow bar represents the **maximum** concentration.

**Figure 3: Key for interpreting the graphs in the following section.**

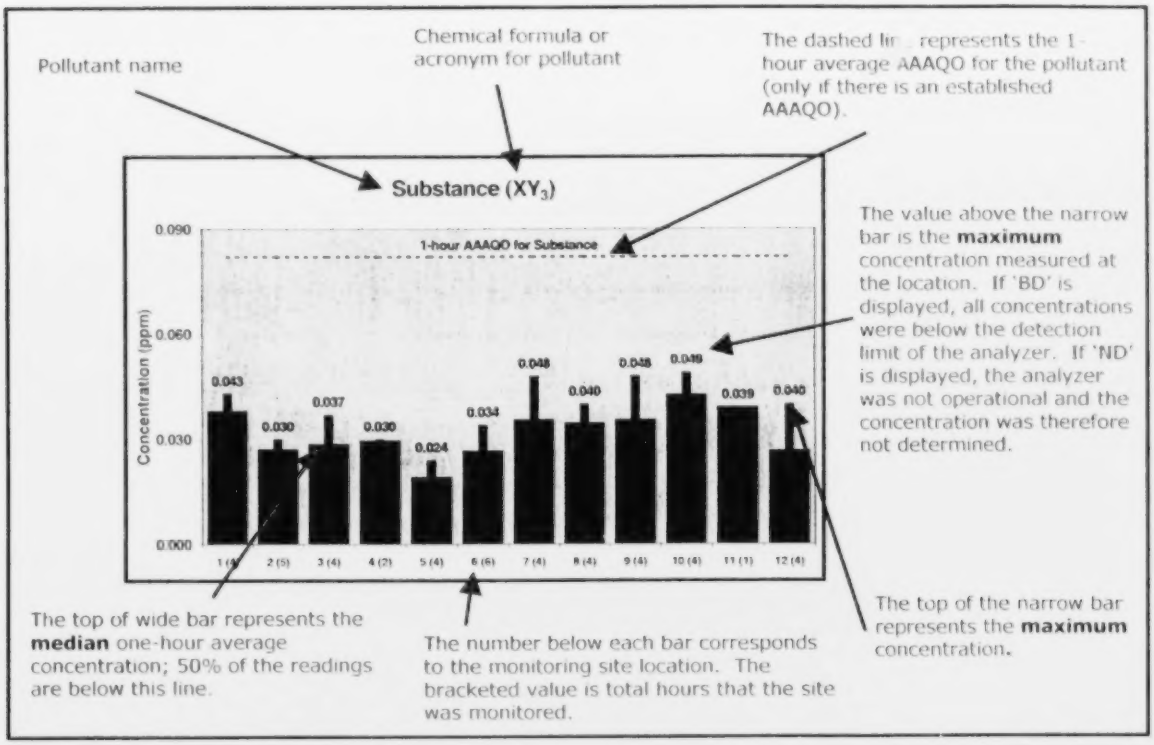

Pollutant name
Chemical formula or acronym for pollutant
The dashed line represents the 1-hour average AAAQO for the pollutant (only if there is an established AAAQO).
Substance ($XY_3$)
1-hour AAAQO for Substance
Concentration (ppm)
0.090
0.060
0.030
0.000
0.043
0.030
0.037
0.030
0.024
0.034
0.048
0.040
0.048
0.049
0.039
0.040
1 (6)
2 (5)
3 (4)
4 (2)
5 (4)
6 (6)
7 (4)
8 (4)
9 (4)
10 (4)
11 (1)
12 (4)
The value above the narrow bar is the **maximum** concentration measured at the location. If 'BD' is displayed, all concentrations were below the detection limit of the analyzer. If 'ND' is displayed, the analyzer was not operational and the concentration was therefore not determined.
The top of wide bar represents the **median** one-hour average concentration; 50% of the readings are below this line.
The number below each bar corresponds to the monitoring site location. The bracketed value is total hours that the site was monitored.
The top of the narrow bar represents the **maximum** concentration.

**Figure 3: Key for interpreting the graphs in the following section.**

## Ammonia ($NH_3$)

Ammonia is a colourless gas with a well-known pungent odour; it is commonly found in household cleaners. $NH_3$ is produced both by natural and man-made sources. Some natural sources of $NH_3$ include the decay of plant material and animal wastes. A small portion is also released during respiration. In Alberta, the fertilizer industry is the main industrial source of $NH_3$. The industry produces synthetic $NH_3$ for either direct application to soil as a fertilizer or as a raw material for use in the production of other high nitrogen fertilizer products. The other major source of $NH_3$ is commercial feedlots, specifically from their large amounts of decaying animal wastes.

$NH_3$ concentrations were highest near fresh sludge spreading site (**Flats Road,** site 3) and lowest 2 km **downwind** (site 2) from the spreading operations. At **Flats Road** , a median one-hour concentration of 0.426 ppm and a maximum concentration of 1.203 ppm were measured. Median one-hour average of 0.004 ppm and maximum of 0.015 ppm were measured 2 km **downwind** from sludge spreading activity.

The **Access Road** (site 1) and **Flats Road** locations both had sludge spreading activity. However, the median one-hour average concentration at the **Access Road** was lower at 0.022 ppm. The maximum $NH_3$ concentration measured at this site was of 0.315 ppm. Elevated $NH_3$ concentrations at **Flats Road** relative to the **Access Road** could have resulted from sampling proximity to spreading operations, differences in sludge composition, freshness of sludge pile.

$NH_3$ is typically not measured at permanent monitoring locations. One-hour average $NH_3$ concentrations near fields with sludge spreading activities were notably higher than $NH_3$ measured during other MAML air quality surveys. Median one-hour $NH_3$ concentrations measured during other surveys ranged from below detection limit to 0.004 ppm. This being said, concentrations measured in the area of Whitecourt were lower than the one-hour average AAAQO of 2 ppm. The AAAQO for ammonia is based on odour perception; the maximum $NH_3$ concentrations measured near pulp mill sludge spreading operations were also lower than AAAQO (Figure 4).

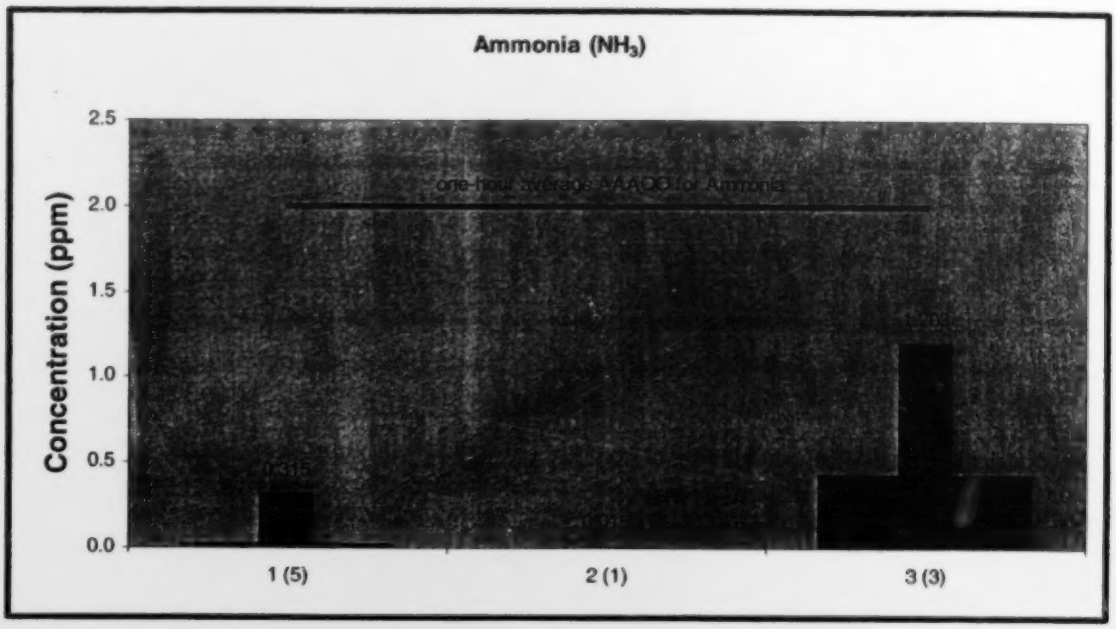



**Figure 4: Median one-hour average and maximum concentrations for ammonia. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

## Ammonia ($NH_3$)

**Ammonia is a colourless gas with a well-known pungent odour; it is commonly found in household cleaners. $NH_3$ is produced both by natural and man-made sources. Some natural sources of $NH_3$ include the decay of plant material and animal waste. A small portion is also released during respiration. In Alberta, the fertilizer industry is the main industrial source of $NH_3$. The industry produces synthetic $NH_3$ for either direct application to soil as a fertilizer or as a raw material for use in the production of other high nitrogen fertilizer products. The other major source of $NH_3$ is commercial feedlots, specifically from their large amounts of decaying animal wastes.**

$NH_3$ concentrations were highest near fresh sludge spreading site (**Flats Road**, site 3) and lowest 2 km **downwind** (site 2) from the spreading operations. At **Flats Road** , a median one-hour concentration of 0.426 ppm and a maximum concentration of 1.203 ppm were measured. Median one-hour average of 0.004 ppm and maximum of 0.015 ppm were measured 2 km **downwind** from sludge spreading activity.

The **Access Road** (site 1) and **Flats Road** locations both had sludge spreading activity. However, the median one-hour average concentration at the **Access Road** was lower at 0.022 ppm. The maximum $NH_3$ concentration measured at this site was of 0.315 ppm. Elevated $NH_3$ concentrations at **Flats Road** relative to the **Access Road** could have resulted from sampling proximity to spreading operations, differences in sludge composition, freshness of sludge pile.

$NH_3$ is typically not measured at permanent monitoring locations. One-hour average $NH_3$ concentrations near fields with sludge spreading activities were notably higher than $NH_3$ measured during other MAML air quality surveys. Median one-hour $NH_3$ concentrations measured during other surveys ranged from below detection limit to 0.004 ppm. This being said, concentrations measured in the area of Whitecourt were lower than the one-hour average AAAQO of 2 ppm. The AAAQO for ammonia is based on odour perception; the maximum $NH_3$ concentrations measured near pulp mill sludge spreading operations were also lower than AAAQO (Figure 4).

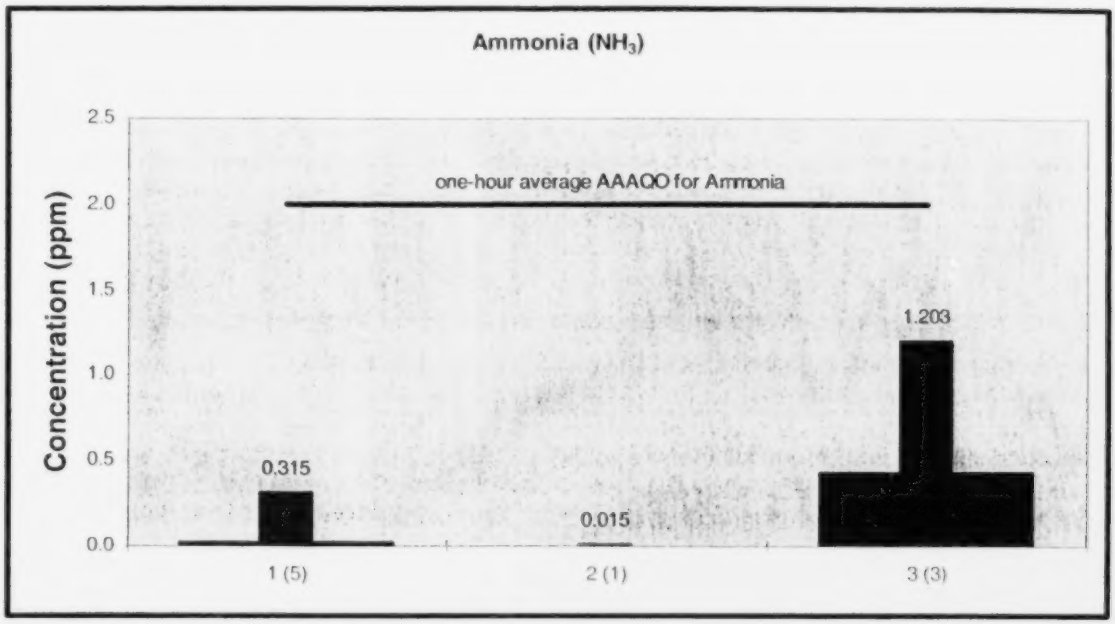



**Figure 4: Median one-hour average and maximum concentrations for ammonia. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

## Hydrogen Sulphide and Total Reduced Sulphur ($H_2S$ and TRS)

Hydrogen sulphide ($H_2S$) is a colourless gas with a rotten egg odour. Total reduced sulphur (TRS) includes hydrogen sulphide, mercaptans, dimethyl sulphide, dimethyl disulphide and other sulphur compounds. Sulphur dioxide is not included in the determination of TRS. Industrial sources of $H_2S$ and TRS include fugitive emissions (leakage) from petroleum refineries, tank farms for unrefined petroleum products, natural gas plants, petrochemical plants, oil sands plants, sewage treatment facilities, pulp and paper plants that use the kraft pulping process, and animal feedlots. Natural sources of $H_2S$ include sulphur hot springs, sloughs, swamps and lakes.

A mechanical pulp mill produces the sludge spread onto agricultural lands east of Whitecourt. Thus, elevated levels of $H_2S$ associated with sludge spreading most probably result from anaerobic decay within the sludge.

At all the monitoring locations $H_2S$ was the main component of TRS. The median $H_2S$ one-hour concentration at the **Access Road** site (site 1) and 2 km **downwind** (site 2) was 0.001 ppm. The overall $H_2S$ concentrations at the **Flats Road** site (site 3) were somewhat higher with a median one-hour concentration of 0.003 ppm. Median one-hour $H_2S$ concentrations at all the monitoring locations were lower than the one-hour average AAAQO.

TRS and $H_2S$ concentrations when measured at Alberta's permanent monitoring stations were largely below detection limit. Median one-hour average $H_2S$ concentrations during other MAML surveys ranged from below detection limit to 0.001 ppm (Banff). Thus overall, $H_2S$ concentrations measured during this survey were comparable to the higher range of concentrations previously measured around Alberta.

Short-term elevated $H_2S$ concentrations were measured at the two sites located near sludge spreading operations (**Flats Road** and **Access Road**). Maximum concentration of 0.024 ppm was measured at the **Access Road**; maximum concentration of 0.008 ppm was measured at the **Flats Road** monitoring location. There was a single short-term exceedance of AAAQO for $H_2S$ (**Access Road**). Although the maximum concentration measured at the **Access Road** is higher than AAAQO, it should be noted that the objective concentration (0.010 ppm) is set for hourly averages and not for short-term (one-minute average) concentrations. The maximum concentrations at these two sites were higher than and equal to the $H_2S$ odour threshold of 0.008 ppm[2]. Thus elevated $H_2S$ concentrations may have contributed to the odours associated with pulp mill sludge spreading. Although it is most likely a combination of compounds are responsible for the odours detected in the area.

2 - Concise International chemical assessment document 53 (WHO). http://www.inchem.org/documents/cicads/cicads/cicad53.htm

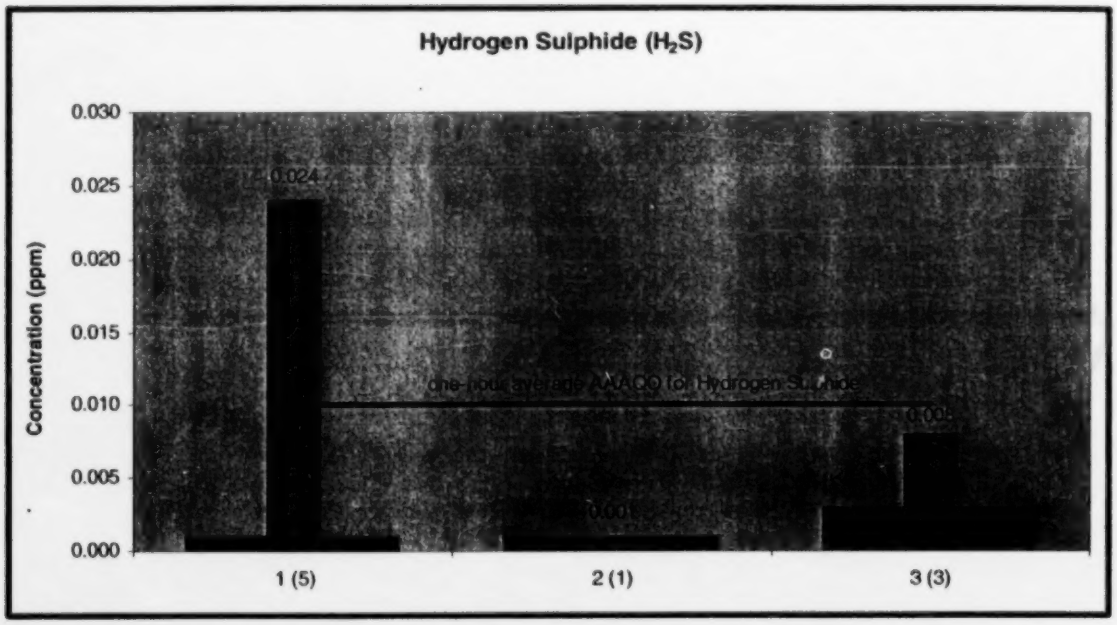



**Figure 5:** Median one-hour average and maximum concentrations for hydrogen sulphide. The maximum and median one-hour average concentrations at the downwind location (Site #2) were equivalent. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)

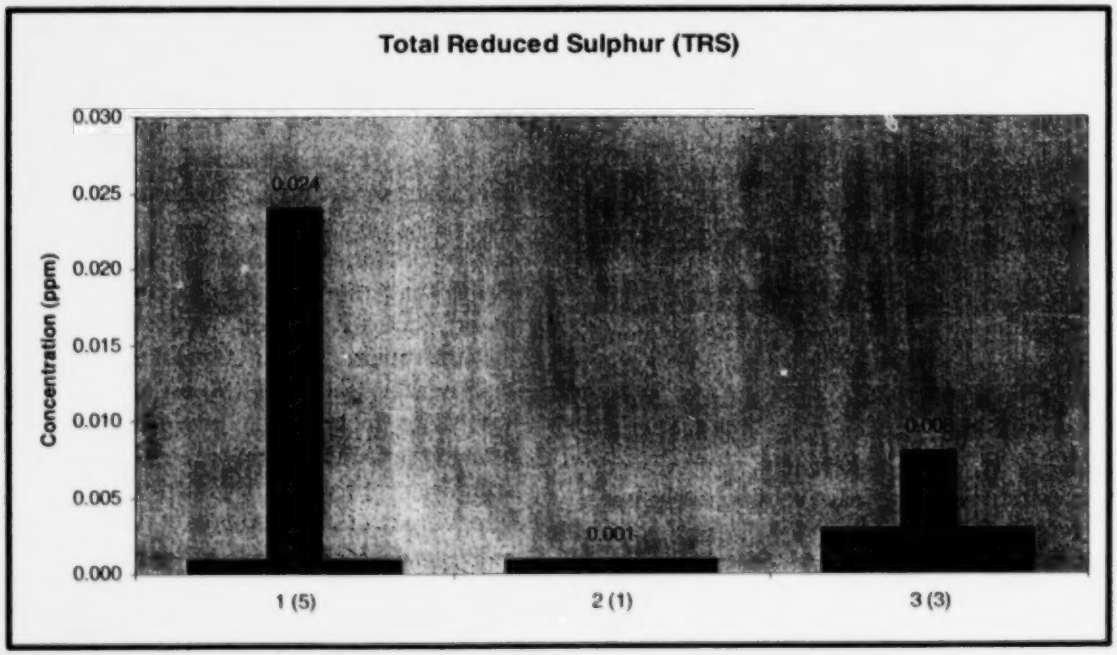



**Figure 6:** Median one-hour average and maximum concentrations for total reduced sulphur. The maximum and median one-hour average concentrations at the downwind location (Site #2) were equivalent. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)

## Hydrogen Sulphide and Total Reduced Sulphur ($H_2S$ and TRS)

**Hydrogen sulphide ($H_2S$) is a colourless gas with a rotten egg odour. Total reduced sulphur (TRS) includes hydrogen sulphide, mercaptans, dimethyl sulphide, dimethyl disulphide and other sulphur compounds. Sulphur dioxide is not included in the determination of TRS. Industrial sources of $H_2S$ and TRS include fugitive emissions (leakages) from petroleum refineries, tank farms for unrefined petroleum products, natural gas plants, petrochemical plants, oil sands plants, sewage treatment facilities, pulp and paper plants that use the kraft pulping process, and animal feedlots. Natural sources of $H_2S$ include sulphur hot springs, sloughs, swamps and lakes.**

A mechanical pulp mill produces the sludge spread onto agricultural lands east of Whitecourt. Thus, elevated levels of $H_2S$ associated with sludge spreading most probably result from anaerobic decay within the sludge.

At all the monitoring locations $H_2S$ was the main component of TRS. The median $H_2S$ one-hour concentration at the **Access Road** site (site 1) and 2 km **downwind** (site 2) was 0.001 ppm. The overall $H_2S$ concentrations at the **Flats Road** site (site 3) were somewhat higher with a median one-hour concentration of 0.003 ppm. Median one-hour $H_2S$ concentrations at all the monitoring locations were lower than the one-hour average AAAQO.

TRS and $H_2S$ concentrations when measured at Alberta's permanent monitoring stations were largely below detection limit. Median one-hour average $H_2S$ concentrations during other MAML surveys ranged from below detection limit to 0.001 ppm (Banff). Thus overall, $H_2S$ concentrations measured during this survey were comparable to the higher range of concentrations previously measured around Alberta.

Short-term elevated $H_2S$ concentrations were measured at the two sites located near sludge spreading operations (**Flats Road** and **Access Road**). Maximum concentration of 0.024 ppm was measured at the **Access Road**; maximum concentration of 0.008 ppm was measured at the **Flats Road** monitoring location. There was a single short-term exceedance of AAAQO for $H_2S$ (**Access Road**). Although the maximum concentration measured at the **Access Road** is higher than AAAQO, it should be noted that the objective concentration (0.010 ppm) is set for hourly averages and not for short-term (one-minute average) concentrations. The maximum concentrations at these two sites were higher than and equal to the $H_2S$ odour threshold of 0.008 ppm[2]. Thus elevated $H_2S$ concentrations may have contributed to the odours associated with pulp mill sludge spreading. Although it is most likely a combination of compounds are responsible for the odours detected in the area.

2 - Concise International chemical assessment document 53 (WHO). http://www.inchem.org/documents/cicads/cicads/cicad53.htm

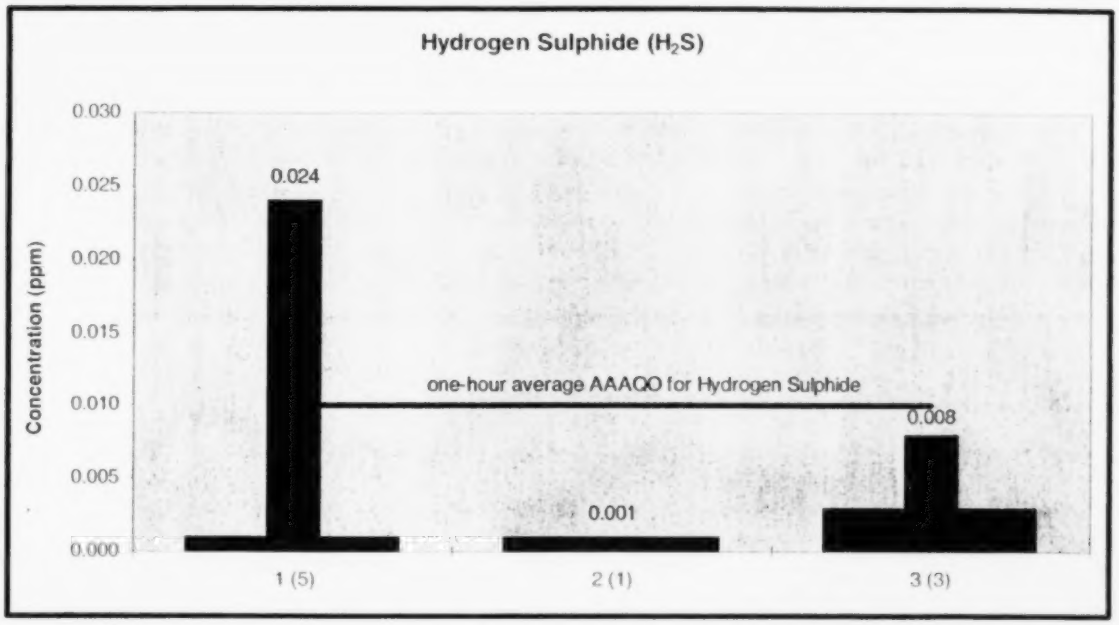



**Figure 5:** **Median one-hour average and maximum concentrations for hydrogen sulphide. The maximum and median one-hour average concentrations at the downwind location (Site #2) were equivalent. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

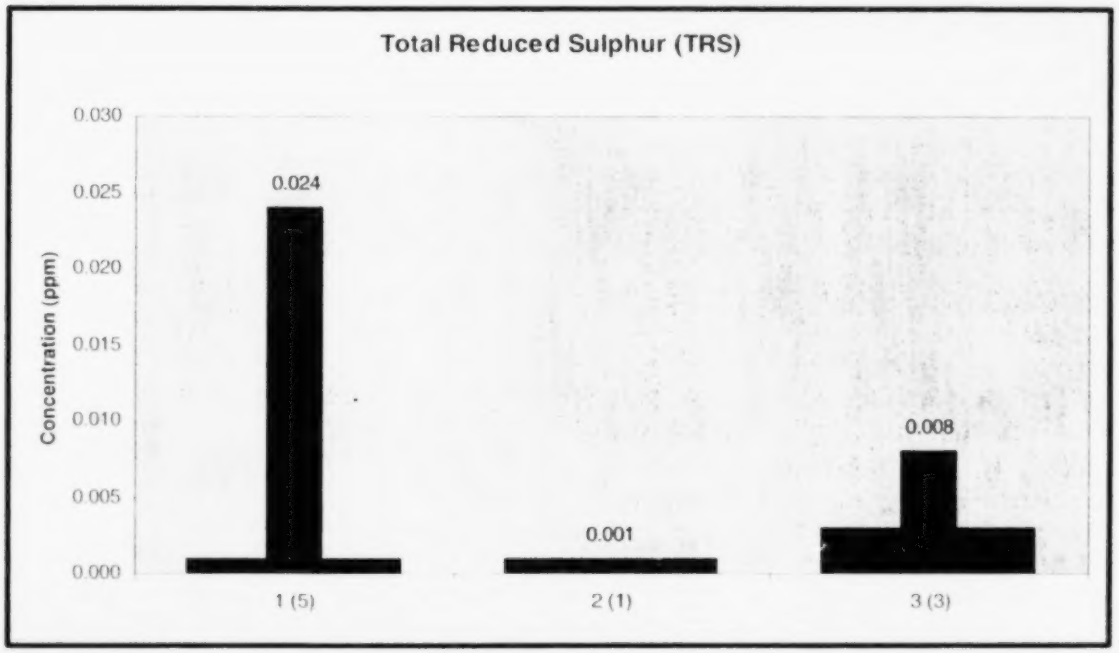



**Figure 6:** **Median one-hour average and maximum concentrations for total reduced sulphur. The maximum and median one-hour average concentrations at the downwind location (Site #2) were equivalent. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

## Hydrocarbons

The term "total hydrocarbons" (THC) refers to a broad family of chemicals that contain carbon and hydrogen atoms. Methane ($CH_4$) is the most common natural hydrocarbon in the earth's atmosphere. Reactive hydrocarbons (RHC) are important because they can contribute to summertime smog or may be toxic at high concentrations. Some sources of hydrocarbons include vehicle emissions, oil and gas processing, chemical processing, dry cleaning, fireplaces, natural gas combustion, aircraft traffic and evaporation of solvents. Hydrocarbons are also naturally emitted by vegetation.

Polycyclic aromatic hydrocarbons (PAHs) are a class of hydrocarbons that are usually contained in soot and smoke. There are more than 100 different PAHs with varying levels of toxicity. They are formed during the incomplete combustion of gasoline, diesel, oil, coal, wood, garbage, or other organic substances. Tobacco smoke and charbroiled meats are common sources of PAHs. Other outdoor PAH sources include vehicle emissions, wood smoke from fireplaces, smoke from forest fires and industrial facilities. PAHs occur in the atmosphere in the vapour phase or in the condensed phase bound to particles. *The monitoring instrument on the MAML will analyze only particulate bound PAHs.*

One-hour average THC concentrations close to the sludge spreading operations were comparable to concentrations measured 2 km **downwind** (site 2). The median one-hour THC concentrations at the three sites ranged from 2.0 to 2.1 ppm. These values are comparable to concentrations measured at other rural sites in Alberta. For example, for 2005, an annual median one-hour concentration of 2.0 ppm was determined for Violet Grove and Caroline.

$CH_4$ was the main component of THC at all three monitoring locations. The median one-hour concentrations at the **Access Road** (site 1), the **downwind** site (and the **Flats Road** site (site 3) were 2.1, 2.0 and 2.1, respectively. One-hour average concentrations for reactive hydrocarbons were below detection limit of the instrument on the MAML.

Short-term elevations in hydrocarbon concentrations were measured at the monitoring locations near sludge loading and spreading activities. The maximum THC concentrations measured at the **Access Road** and **Flats Road** were of 6.6 and 3.7 ppm, respectively. The maximum $CH_4$ concentrations at these sites were 6.1 ppm and 3.5 ppm, respectively. The maximum PAHs concentration of 111 ng/m$^3$ measured at the **Access Road** was notably higher than the maximum concentration of 11 ng/m$^3$ measured at the **Flats Road** site. These short-term increases in hydrocarbons most probably resulted from vehicle emissions, such as those used in the sludge loading and spreading operations.

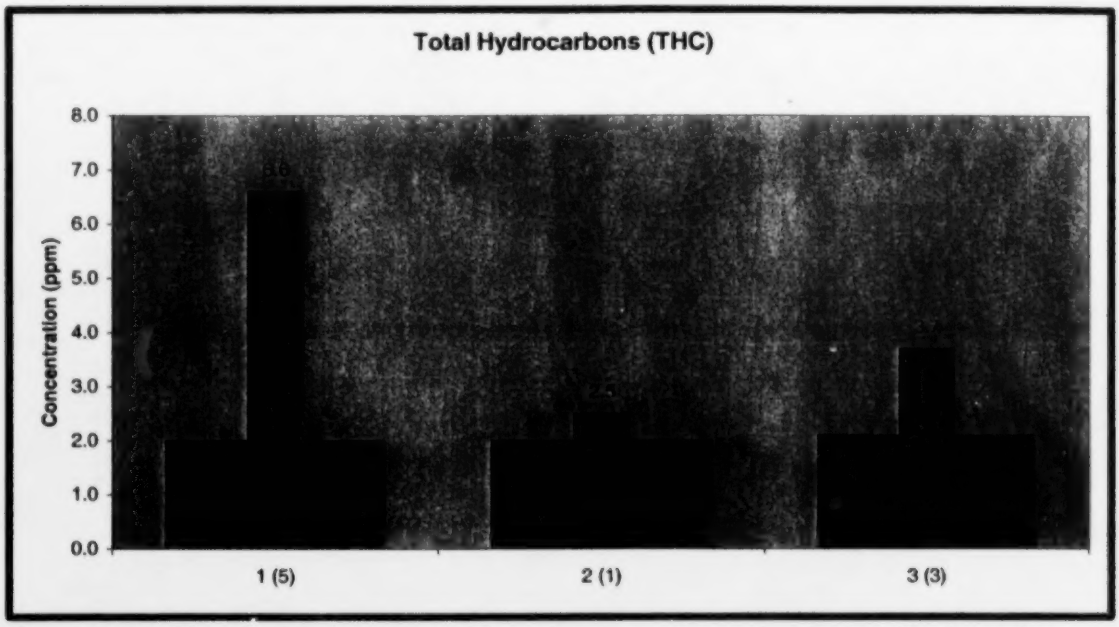



**Figure 7: Median one-hour average and maximum concentration for total hydrocarbons. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

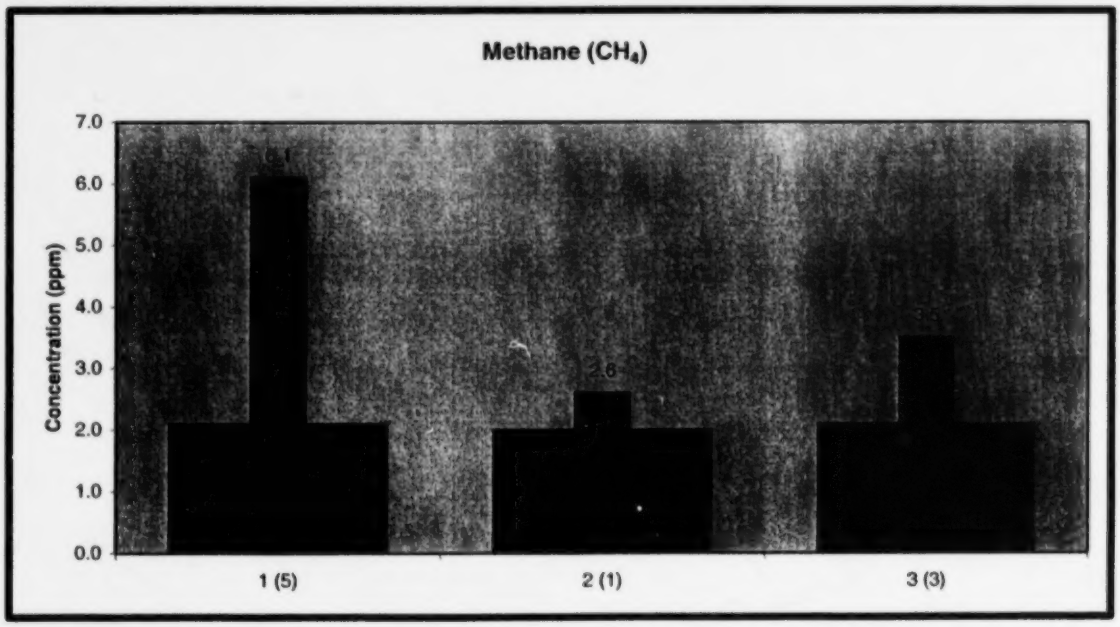



**Figure 8: Median one-hour average and maximum concentrations for methane. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

## Hydrocarbons

**The term "total hydrocarbons" (THC) refers to a broad family of chemicals that contain carbon and hydrogen atoms. Methane ($CH_4$) is the most common natural hydrocarbon in the earth's atmosphere. Reactive hydrocarbons (RHC) are important because they can contribute to summertime smog or may be toxic at high concentrations. Some sources of hydrocarbons include vehicle emissions, oil and gas processing, chemical processing, dry cleaning, fireplaces, natural gas combustion, aircraft traffic and evaporation of solvents. Hydrocarbons are also naturally emitted by vegetation.**

**Polycyclic aromatic hydrocarbons (PAHs) are a class of hydrocarbons that are usually contained in soot and smoke. There are more than 100 different PAHs with varying levels of toxicity. They are formed during the incomplete combustion of gasoline, diesel, oil, coal, wood, garbage or other organic substances. Tobacco smoke and charbroiled meats are common sources of PAHs. Other outdoor PAH sources include vehicle emissions, wood smoke from fireplaces, smoke from forest fires and industrial facilities. PAHs occur in the atmosphere in the vapour phase or in the condensed phase bound to particles. *The monitoring instrument on the MAML will analyze only particulate bound PAHs.***

One-hour average THC concentrations close to the sludge spreading operations were comparable to concentrations measured 2 km **downwind** (site 2). The median one-hour THC concentrations at the three sites ranged from 2.0 to 2.1 ppm. These values are comparable to concentrations measured at other rural sites in Alberta. For example, for 2005, an annual median one-hour concentration of 2.0 ppm was determined for Violet Grove and Caroline.

$CH_4$ was the main component of THC at all three monitoring locations. The median one-hour concentrations at the **Access Road** (site 1), the **downwind** site (and the **Flats Road** site (site 3) were 2.1, 2.0 and 2.1, respectively. One-hour average concentrations for reactive hydrocarbons were below detection limit of the instrument on the MAML.

Short-term elevations in hydrocarbon concentrations were measured at the monitoring locations near sludge loading and spreading activities. The maximum THC concentrations measured at the **Access Road** and **Flats Road** were of 6.6 and 3.7 ppm, respectively. The maximum $CH_4$ concentrations at these sites were 6.1 ppm and 3.5 ppm, respectively. The maximum PAHs concentration of 111 ng/m$^3$ measured at the **Access Road** was notably higher than the maximum concentration of 11 ng/m$^3$ measured at the **Flats Road** site. These short-term increases in hydrocarbons most probably resulted from vehicle emissions, such as those used in the sludge loading and spreading operations.

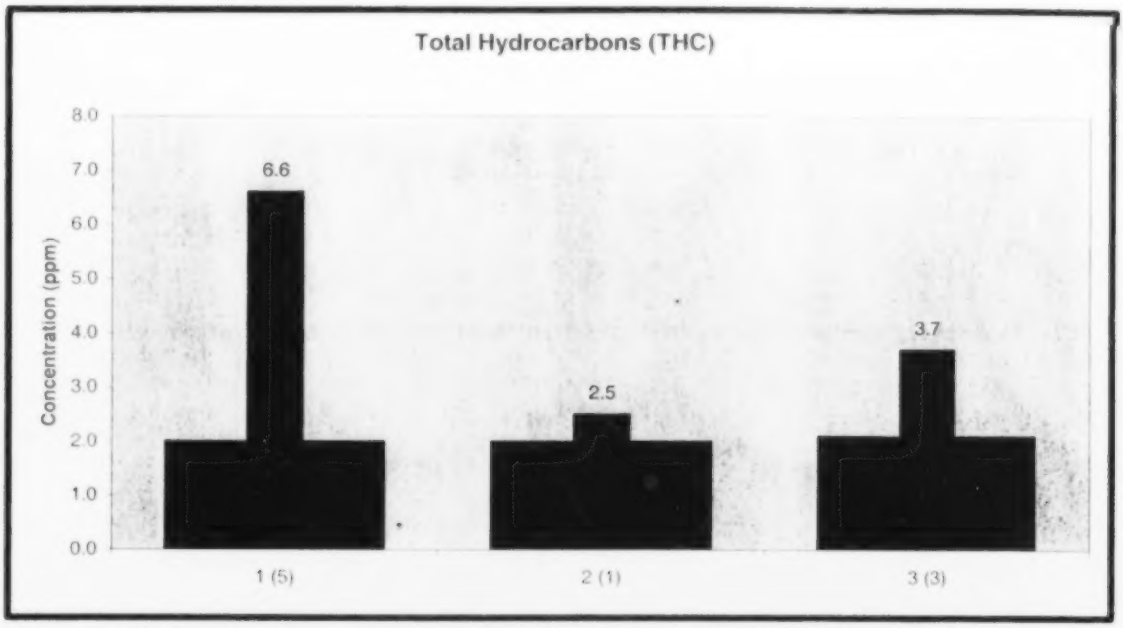



**Figure 7: Median one-hour average and maximum concentration for total hydrocarbons. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

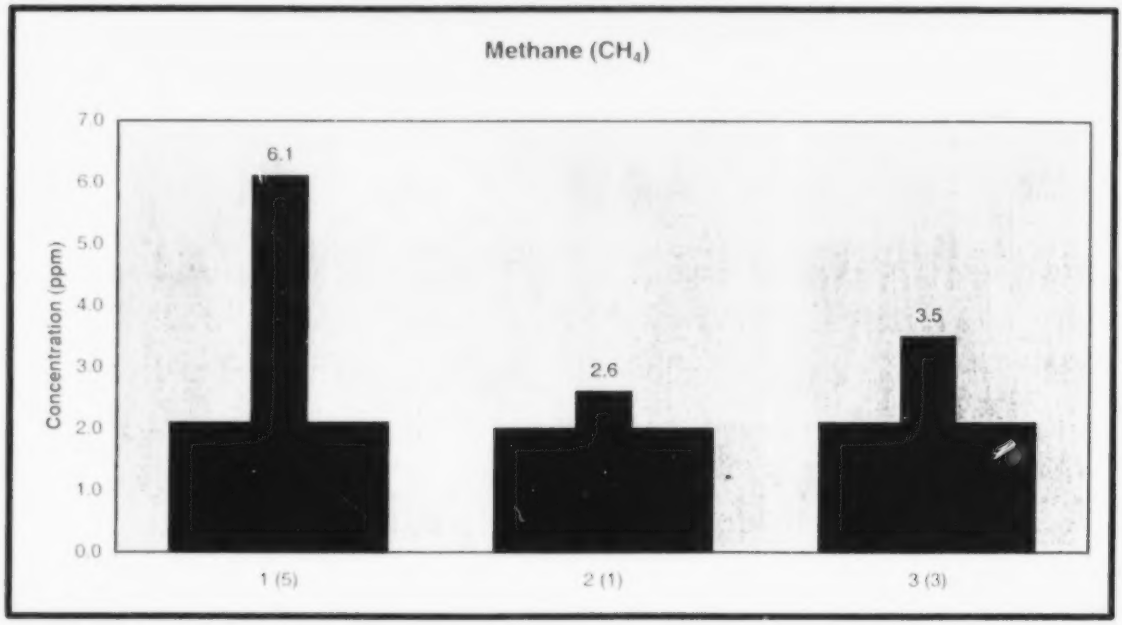



**Figure 8: Median one-hour average and maximum concentrations for methane. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

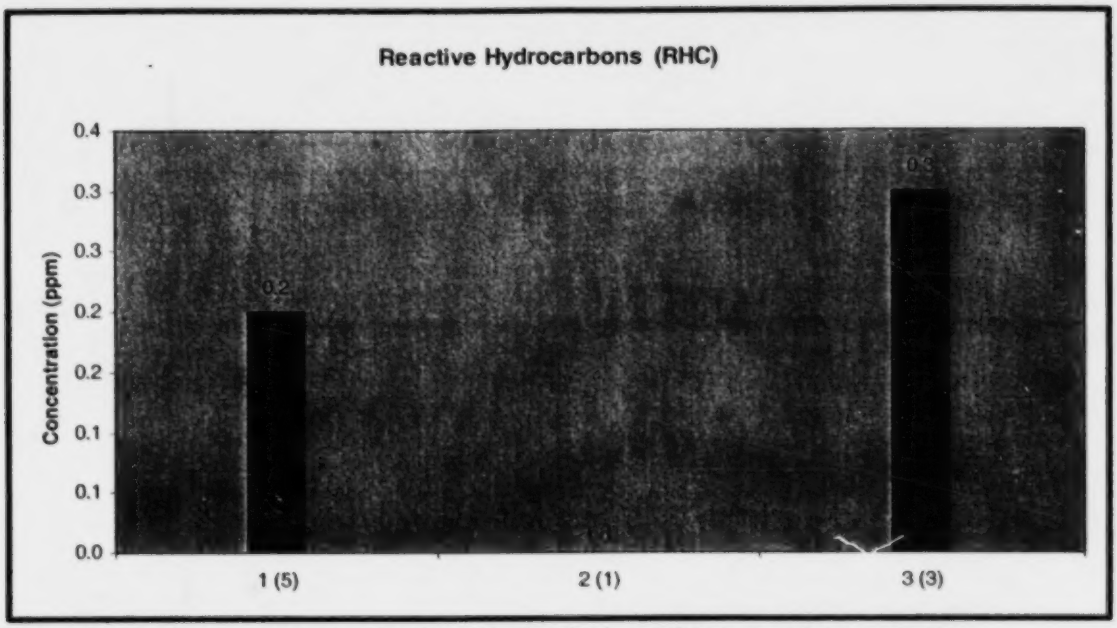



**Figure 9: Maximum concentration for reactive hydrocarbons, one-hour average concentrations were below detection limit. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

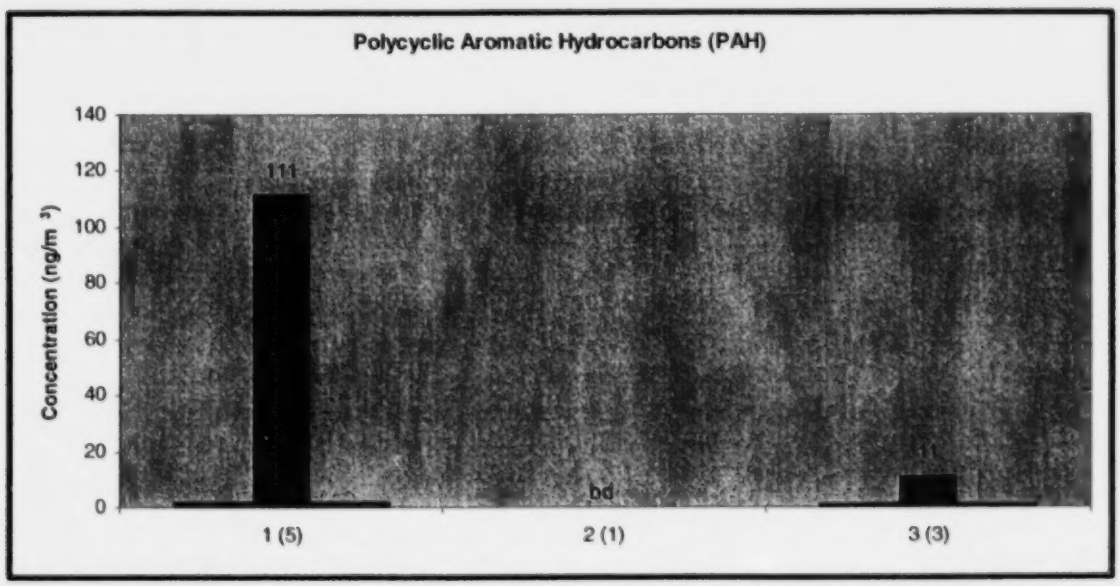



**Figure 10: Maximum concentration for polycyclic aromatic hydrocarbons, one-hour average concentrations were below detection limit. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

## Particulate Matter (TSP, $PM_{10}$, $PM_{2.5}$)

**Total suspended particulates (TSP) refer to all particles up to 500 µm (micrometers) in diameter (a human hair is about 70 µm in diameter) and are important primarily from a nuisance perspective. Particles less than 10 µm in diameter ($PM_{10}$) can be inhaled into the nose and throat while smaller particles, less than 2.5 µm in diameter ($PM_{2.5}$), can penetrate into the lungs. Sources of coarse particulate matter ($PM_{10}$) include soil dust, re-suspended road dust, agricultural dust (e.g., harvest), smoke from forest fires and wood burning. Fine particulate matter ($PM_{2.5}$) can originate in the atmosphere because of condensation processes. $PM_{2.5}$ can also from through combustion processes such as vehicles emissions, industrial emissions, wood burning and forest fires.**

Median one-hour $PM_{2.5}$ concentrations at all three sites were similar with concentrations ranging from 1-2 µg/m$^3$. These concentrations are comparable to those measured at rural monitoring sites such as Fort Chipewyan (1 µg/m$^3$) and Fort McKay (2 µg/m$^3$). Higher $PM_{2.5}$ concentrations are typically measured at urban centres such as Edmonton and Calgary, where median one-hour concentrations are on the order of 5 µg/m$^3$.

Median one-hour concentrations of TSP and $PM_{10}$ were notably higher at the two monitoring locations close to sludge loading and spreading activities. $PM_{10}$ and TSP median one-hour concentrations at the **Access Road** (site 1) sample location were 16 and 28 µg/m$^3$, respectively. Median $PM_{10}$ and TSP concentrations at the new sludge spreading location (**Flats Road,** site 3) were 23 and 43 µg/m$^3$, respectively. Similarly, short-term increased in particulate matter were more pronounced close to sludge spreading and loading activities. This is illustrated by the maximum concentrations presented in Figures 12-14.

TSP and $PM_{10}$ are not regularly monitored at Alberta's permanent monitoring stations. Median one-hour TSP concentrations for other MAML survey ranged from 7 µg/m$^3$ (Banff, 2003) to 47µg/m$^3$ (Whitecourt/Swan Hills/ Shiningbank Lake, 2001). Elevated level of particulates during this survey, most probably are due to re-suspended road and solid dust with some contribution from vehicle emissions. Re-suspension of road and soil dust may have been promoted by sludge spreading and loading vehicles operating in the fields (see Photographs in Figure 2).

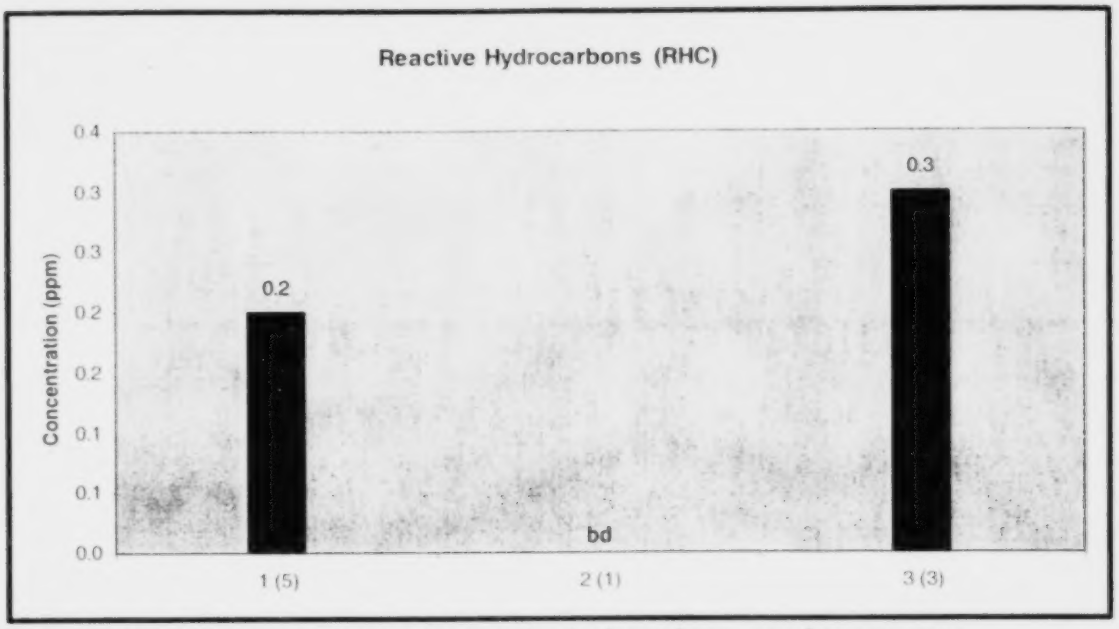



**Figure 9: Maximum concentration for reactive hydrocarbons, one-hour average concentrations were below detection limit. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

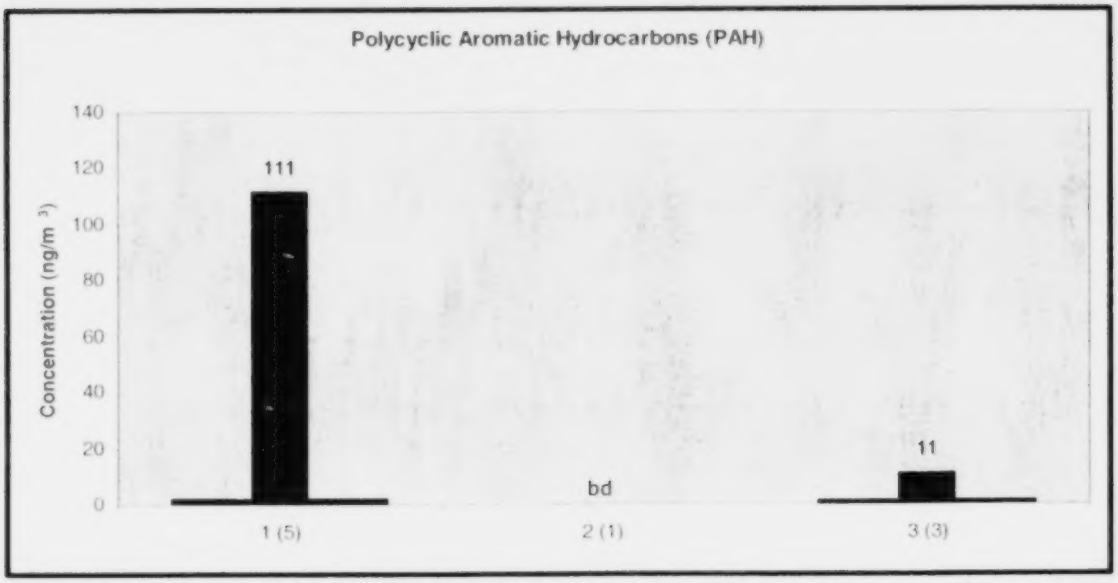



**Figure 10: Maximum concentration for polycyclic aromatic hydrocarbons, one-hour average concentrations were below detection limit. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

## Particulate Matter (TSP, $PM_{10}$, $PM_{2.5}$)

**Total suspended particulates (TSP) refer to all particles up to 500 μm (micrometers) in diameter (a human hair is about 70 μm in diameter) and are important primarily from a nuisance perspective. Particles less than 10 μm in diameter ($PM_{10}$) can be inhaled into the nose and throat while smaller particles, less than 2.5 μm in diameter ($PM_{2.5}$), can penetrate into the lungs. Sources of coarse particulate matter ($PM_{10}$) include soil dust, re-suspended road dust, agricultural dust (e.g., harvest), smoke from forest fires and wood burning. Fine particulate matter ($PM_{2.5}$) can originate in the atmosphere because of condensation processes. $PM_{2.5}$ can also from through combustion processes such as vehicles emissions, industrial emissions, wood burning and forest fires.**

Median one-hour $PM_{2.5}$ concentrations at all three sites were similar with concentrations ranging from 1-2 $\mu g/m^3$. These concentrations are comparable to those measured at rural monitoring sites such as Fort Chipewyan (1 $\mu g/m^3$) and Fort McKay (2 $\mu g/m^3$). Higher $PM_{2.5}$ concentrations are typically measured at urban centres such as Edmonton and Calgary, where median one-hour concentrations are on the order of 5 $\mu g/m^3$.

Median one-hour concentrations of TSP and $PM_{10}$ were notably higher at the two monitoring locations close to sludge loading and spreading activities. $PM_{10}$ and TSP median one-hour concentrations at the **Access Road** (site 1) sample location were 16 and 28 $\mu g/m^3$, respectively. Median $PM_{10}$ and TSP concentrations at the new sludge spreading location (**Flats Road,** site 3) were 23 and 43 $\mu g/m^3$, respectively. Similarly, short-term increased in particulate matter were more pronounced close to sludge spreading and loading activities. This is illustrated by the maximum concentrations presented in Figures 12-14.

TSP and $PM_{10}$ are not regularly monitored at Alberta's permanent monitoring stations. Median one-hour TSP concentrations for other MAML survey ranged from 7 $\mu g/m^3$ (Banff, 2003) to 47 $\mu g/m^3$ (Whitecourt/Swan Hills/ Shiningbank Lake, 2001). Elevated level of particulates during this survey, most probably are due to re-suspended road and solid dust with some contribution from vehicle emissions. Re-suspension of road and soil dust may have been promoted by sludge spreading and loading vehicles operating in the fields (see Photographs in Figure 2).

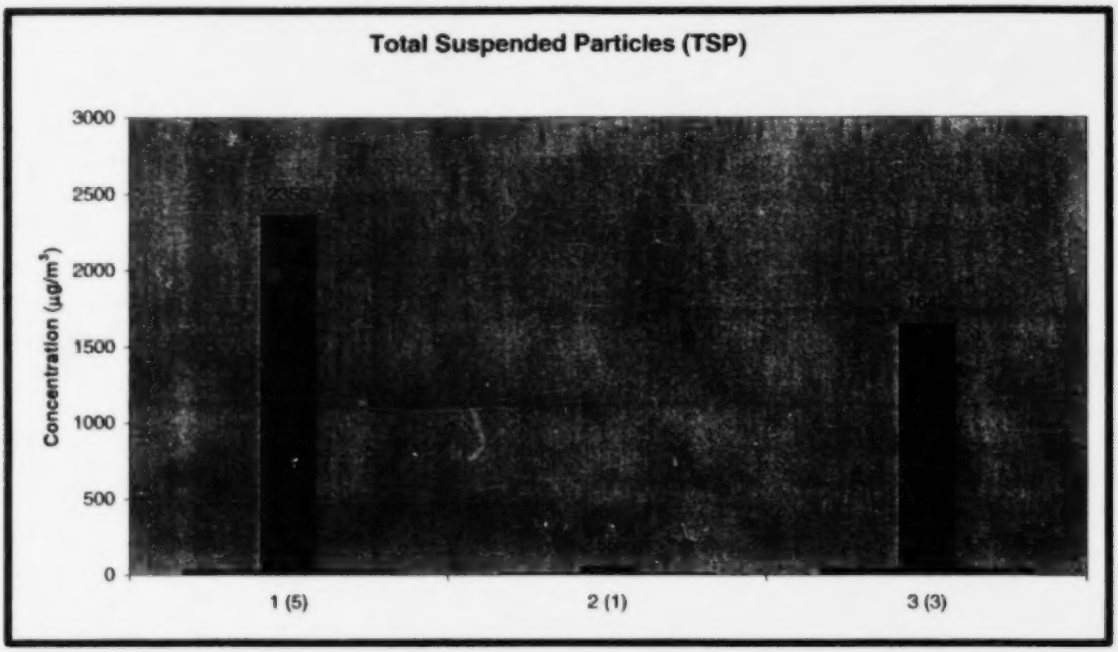



**Figure 11: Median one-hour and maximum concentrations for total suspended particles. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

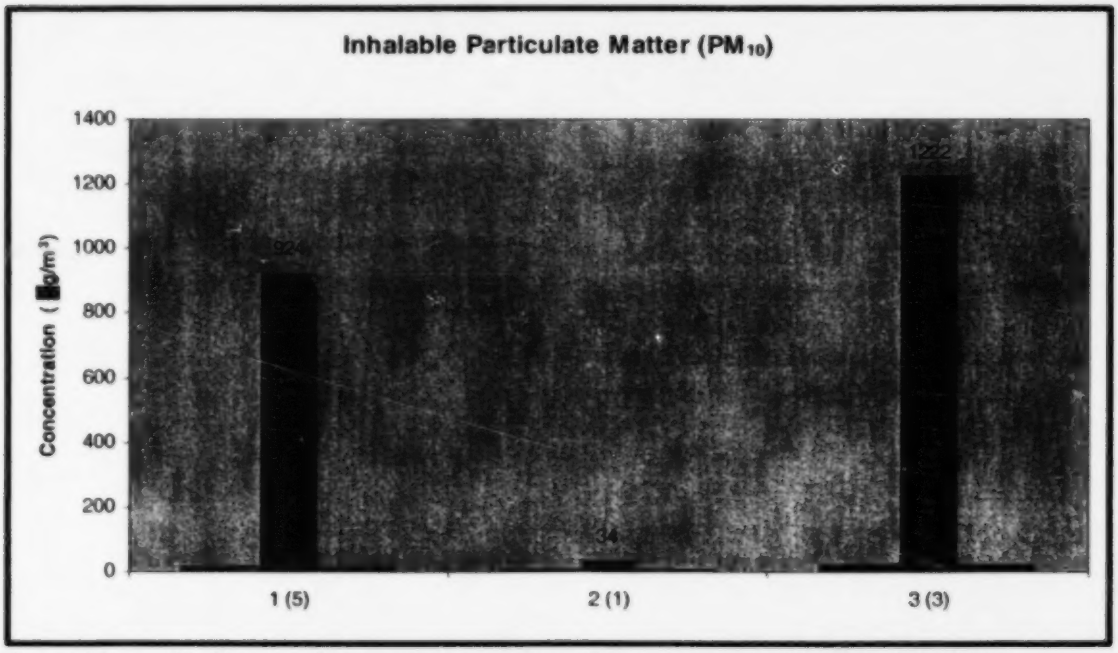



**Figure 12: Median one-hour average and maximum concentrations for inhalable particulate matter. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

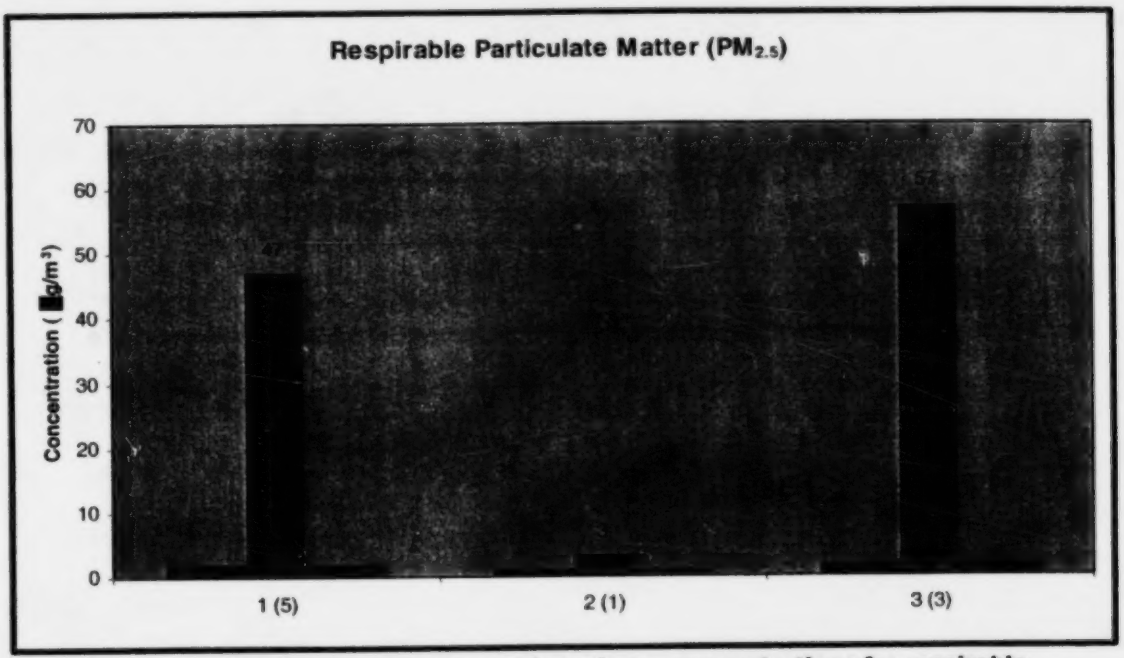



**Figure 13: Median one-hour average and maximum concentrations for respirable particulate matter. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)**

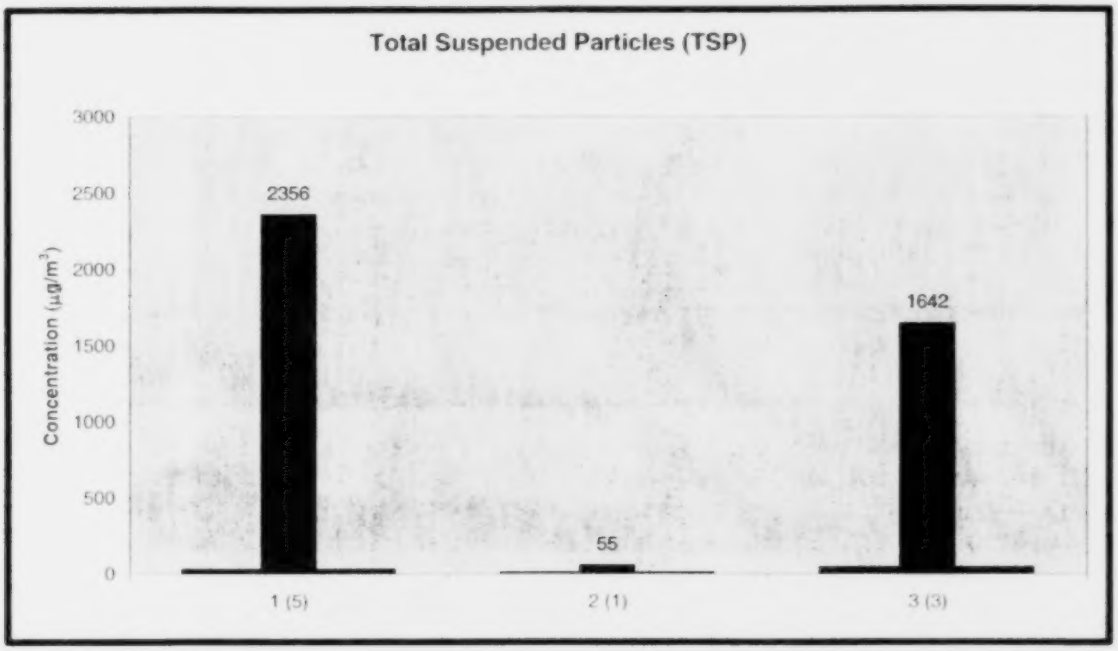



**Figure 11:** Median one-hour and maximum concentrations for total suspended particles. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)

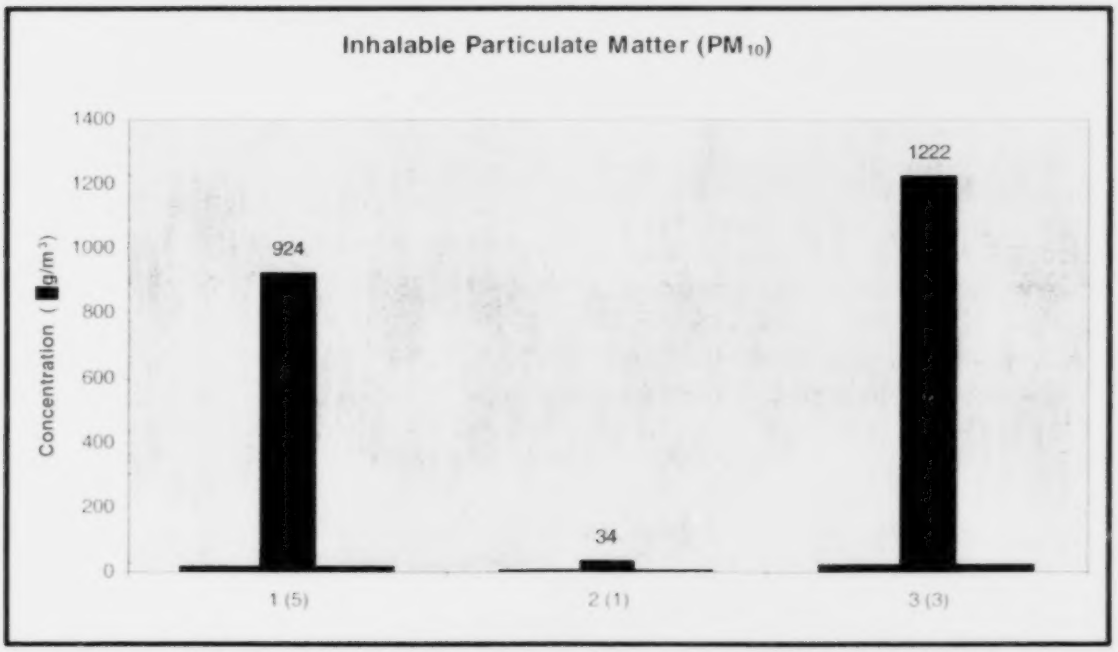



**Figure 12:** Median one-hour average and maximum concentrations for inhalable particulate matter. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)

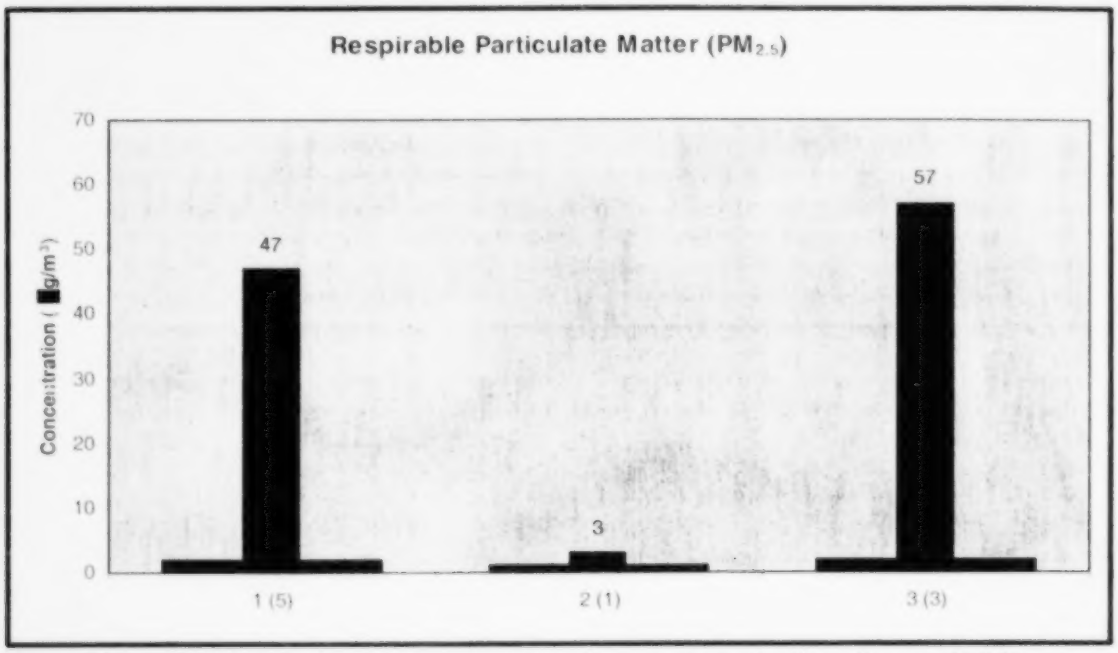



**Figure 13:** Median one-hour average and maximum concentrations for respirable particulate matter. (Site 1 - Access Road, Site 2 –downwind, Site 3 – Flats Road)

## Volatile Organic Compounds (VOCs)

**Volatile organic compounds include a large group of chemicals containing carbon and hydrogen atoms that can react quickly to form other chemicals in atmosphere. It should be noted that the terms 'reactive hydrocarbons (RHC)' and 'volatile organic compounds (VOC)' are often used interchangeably and both generally refer to the group of substances that form during combustion and evaporation of solvents and fuels. VOCs are important because they can: (1) react with oxides of nitrogen in the presence of sunlight to form ozone and photochemical smog; and (2) be toxic to humans, animals or vegetation.**

**The major sources of VOCs are vegetation, automobile emissions, gasoline marketing and storage tanks, petroleum and chemical industries, dry cleaning, fireplaces, natural gas combustion and aircraft. VOC emissions from natural sources, such as forests, grasslands and swamps, are estimated to be almost six times greater than human sources. Individual VOCs are also produced from the evaporation of solvents and organic chemicals as well as from leaking valves, flanges, pumps and compressors at industrial facilities. The major source of VOCs in most urban areas is vehicle exhaust emissions.**

A total of five air samples were taken for VOCs analysis. The location of these samples and their proximity to MAML survey sites are shown in Figure 2. In addition to samples taken near the three MAML monitoring locations, a **background** and an **upwind** sample were also taken.

In addition to 109 target VOCs, any compounds resolved by the analysis method are also reported. For these compounds a match quality is assigned. The match quality indicates the confidence level at which the compound was identified. In a few cases the Match quality were too low to report (MQ less than 50%). When the reported match quality was between 50 and 80%, the concentrations measured are reported but have been flagged to indicate a lower match quality. Alberta Research Council in Vegreville, Alberta conducted VOCs analysis for this survey.

A list of all the VOCs reported can be found in Appendix A. VOCs with concentrations above detection limit are shown in Table 4. Also shown in Table 4 are odour thresholds for a number of the compounds.

Overall VOCs concentrations for samples taken in the Whitecourt area were low. In number of cases VOCs concentrations near spreading operations were comparable or lower than concentrations determined for the **background** sample (Table 2). The exception was toluene, which had elevated concentration at the **Access Road** and **Flats Road** monitoring locations. Concentrations at the two sites were 2.63 and 0.56 $\mu g/m^3$, compared to a background concentration of 0.11 $\mu g/m^3$. Motor vehicle emissions and evaporation losses are the main sources of ambient toluene concentrations. Elevated levels of toluene near sludge spreading operations may be due to nearby vehicles emissions. However, Toluene from vehicle emission is typically associated with ethylbenzene and xylene[1]. Concentration of the ethylbenzene and all isomers of xylene at all the monitoring locations were below

1 Guidelines at a glance. Canadian soil quality guidelines: Toluene. Retrieved November 16 from http://www.ec.gc.ca/ceqg-rcqe/English/Pdf/GAAG_TolueneSoil_e.pdf

## Volatile Organic Compounds (VOCs)

**Volatile organic compounds include a large group of chemicals containing carbon and hydrogen atoms that can react quickly to form other chemicals in atmosphere. It should be noted that the terms 'reactive hydrocarbons (RHC)' and 'volatile organic compounds (VOC)' are often used interchangeably and both generally refer to the group of substances that form during combustion and evaporation of solvents and fuels. VOCs are important because they can: (1) react with oxides of nitrogen in the presence of sunlight to form ozone and photochemical smog, and (2) be toxic to humans, animals or vegetation.**

**The major sources of VOCs are vegetation, automobile emissions, gasoline marketing and storage tanks, petroleum and chemical industries, dry cleaning, fireplaces, natural gas combustions and aircraft. VOC emissions from natural sources, such as forests, grasslands and swamps, are estimated to be almost 8x times greater than human sources. Individual VOCs are also produced from the evaporation of solvents and organic chemicals as well as from leaking valves, flanges, pumps and compressors at industrial facilities. The major source of VOCs in most urban areas is vehicle exhaust emissions.**

A total of five air samples were taken for VOCs analysis. The location of these samples and their proximity to MAML survey sites are shown in Figure 2. In addition to samples taken near the three MAML monitoring locations, a **background** and an **upwind** sample were also taken.

In addition to 109 target VOCs, any compounds resolved by the analysis method are also reported. For these compounds a match quality is assigned. The match quality indicates the confidence level at which the compound was identified. In a few cases the Match quality were too low to report (MQ less than 50%). When the reported match quality was between 50 and 80%, the concentrations measured are reported but have been flagged to indicate a lower match quality. Alberta Research Council in Vegreville, Alberta conducted VOCs analysis for this survey.

A list of all the VOCs reported can be found in Appendix A. VOCs with concentrations above detection limit are shown in Table 4. Also shown in Table 4 are odour thresholds for a number of the compounds.

Overall VOCs concentrations for samples taken in the Whitecourt area were low. In number of cases VOCs concentrations near spreading operations were comparable or lower than concentrations determined for the **background** sample (Table 2). The exception was toluene, which had elevated concentration at the **Access Road** and **Flats Road** monitoring locations. Concentrations at the two sites were 2.63 and 0.56 $\mu g/m^3$, compared to a background concentration of 0.11 $\mu g/m^3$. Motor vehicle emissions and evaporation losses are the main sources of ambient toluene concentrations. Elevated levels of toluene near sludge spreading operations may be due to nearby vehicles emissions. However, Toluene from vehicle emission is typically associated with ethylbenzene and xylene[1]. Concentration of the ethylbenzene and all isomers of xylene at all the monitoring locations were below

1 Guidelines at a glance. Canadian soil quality guidelines: Toluene. Retrieved November 16 from http://www.ec.gc.ca/ceqg-rcqe/English/Pdf/GAAG_TolueneSoil_e.pdf

detection limit. Thus, evaporation losses from pulp mill sludge and/or soil cannot be eliminated as a potential source. This being said, toluene concentrations at all monitoring locations were below the AAAQO of 1880 ppm and odour threshold of 8025 ppm.

With the exception of acetaldehyde concentration (2.67 $\mu g/m^3$) measured 2km **downwind** from spreading operations, all other concentrations were below AAAQO and odour threshold. It is unlikely that an elevated concentration at this site was the result of sludge spreading operations. Acetaldehyde concentrations near pulp mill sludge spreading operations were not detected or were significantly lower. Elevated p-cymene, $\alpha$-p-dimethylstyrene and (E)-4-octane concentrations at the **upwind** site (VOC sample #2), can also not be related to sludge spreading operations.

**Table 2:One-hour average concentration of select VOCs measured in the Whitecourt area.**

| Sample Site | VOC sample 1 | VOC Sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 | AAAQO | Odour Threshold | | |
|---|---|---|---|---|---|---|---|---|---|
| Location of Sample | **Background** Sample: Lookout Point on Blue Ridge Road | **Upwind** Flats Road and Trestle Road | 300 m East of New Pile Loading, **Flats Road** | At Loading Operations; **Access Road**, 1.5 mi East of Trestle Road | 2 km **downwind** from Spreading Operations | | Low | High | Source |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | | | | |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 | | | | |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ | |
| (E)-4-Octene | ND | 5.66[a] | ND | ND | ND | -- | -- | -- | -- |
| α-p-dimethylstyrene | Nd | 0.52 | ND | ND | ND | 215 | 149 | | 2 |
| 2-Propanone | 1.37[a] | 1.37[a] | 1.27 | Low MQ | 2.80[a] | 5900 | 47467 | 1613860 | 1 |
| Acetaldehyde | ND | Low MQ | Low MQ | ND | 2.67 | 90 | 0.2 | 4140 | 1 |
| Alpha-Pinene | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | -- | 100 | | 2 |
| Benzene | 0.38 | 0.41 | 0.40 | 0.34 | 0.38 | 30 | 4500 | 270000 | 1 |
| Carbon disulphide | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 30 | 650 | | 2 |
| Carbon tetrachloride | 0.48 | 0.44 | 0.44 | 0.47 | 0.48 | -- | 60000 | 128400 | 1 |
| Carbonyl sulphide | 1.01 | 1.32 | 0.74 | 1.20 | 1.01 | -- | 1350 | | 2 |
| cis-1,2-Dichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -- | -- | -- | -- |
| Freon-11 | 0.73 | 0.71 | 0.72 | 0.67 | 0.73 | -- | 28000 | 1170400 | 1 |
| Freon-113 | 0.16 | 0.00 | 0.00 | 0.16 | 0.16 | -- | 342000 | 1026000 | 1 |
| Hexane | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 | -- | 77141 | | 1 |
| Isopentane | 0.14 | 0.27 | 0.13 | 0.30 | 0.14 | -- | 3833 | | 2 |
| Isoprene | 0.74 | 0.77 | 0.00 | 0.15 | 0.74 | -- | 134 | | 2 |
| p-Cymene | 0.00 | 4.71 | 0.00 | 0.00 | 0.00 | -- | -- | -- | -- |
| Toluene | 0.11 | 0.12 | 2.63 | 0.56 | 0.11 | 1880 | 8025 | 150000 | 1 |
| Trichloromonofluoromethane | ND | 0.39[a] | 0.44 | ND | ND | -- | -- | -- | -- |

**NOTES:**

**µg/m³** = micrograms per cubic metre

**ND** - not determined

**Low MQ** - Match quality was lower than 50%. Match quality quantifies the confidence with which the organic compound was identified. All data with match quality lower than 50% were removed.

**a** - Data Match quality higher than 50% but lower than 80%.

Odour threshold source

**1** *Odor thresholds and limitations levels of several chemical substances: A review*. Published by American industrial hygiene association and the 3M 2001 respirator selection guide.

**2** Nagata Y., *Measurement of Odor Threshold by Triangle Odor Bag Method*, Bulletin of Japan Environmental Sanitation Center, (1990), 17, pp. 77-89. On http://www.odour.cz/english/thresholds/thresholds.html

**Table 2:One-hour average concentration of select VOCs measured in the Whitecourt area.**

| Sample Site | VOC sample 1 | VOC Sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 | AAAQO | Odour Threshold | | |
|---|---|---|---|---|---|---|---|---|---|
| Location of Sample | **Background** Sample: Lookout Point on Blue Ridge Road | **Upwind** Flats Road and Trestle Road | 300 m East of New Pile Loading, **Flats Road** | At Loading Operations; **Access Road**, 1.5 mi East of Trestle Road | 2 km **downwind** from Spreading Operations | | Low | High | Source |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | | | | |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 | | | | |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ | |
| (E)-4-Octene | ND | 5.66[a] | ND | ND | ND | -- | -- | -- | -- |
| α-p-dimethylstyrene | Nd | 0.52 | ND | ND | ND | 215 | 149 | | 2 |
| 2-Propanone | 1.37[a] | 1.37[a] | 1.27 | Low MQ | 2.80[a] | 5900 | 47467 | 1613860 | 1 |
| Acetaldehyde | ND | Low MQ | Low MQ | ND | 2.67 | 90 | 0.2 | 4140 | 1 |
| Alpha-Pinene | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | -- | 100 | | 2 |
| Benzene | 0.38 | 0.41 | 0.40 | 0.34 | 0.38 | 30 | 4500 | 270000 | 1 |
| Carbon disulphide | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 30 | 650 | | 2 |
| Carbon tetrachloride | 0.48 | 0.44 | 0.44 | 0.47 | 0.48 | -- | 60000 | 128400 | 1 |
| Carbonyl sulphide | 1.01 | 1.32 | 0.74 | 1.20 | 1.01 | -- | 1350 | | 2 |
| cis-1,2-Dichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -- | -- | -- | -- |
| Freon-11 | 0.73 | 0.71 | 0.72 | 0.67 | 0.73 | -- | 28000 | 1170400 | 1 |
| Freon-113 | 0.16 | 0.00 | 0.00 | 0.16 | 0.16 | -- | 342000 | 1026000 | 1 |
| Hexane | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 | -- | 77141 | | 1 |
| Isopentane | 0.14 | 0.27 | 0.13 | 0.30 | 0.14 | -- | 3833 | | 2 |
| Isoprene | 0.74 | 0.77 | 0.00 | 0.15 | 0.74 | -- | 134 | | 2 |
| p-Cymene | 0.00 | 4.71 | 0.00 | 0.00 | 0.00 | -- | -- | -- | -- |
| Toluene | 0.11 | 0.12 | 2.63 | 0.56 | 0.11 | 1880 | 8025 | 150000 | 1 |
| Trichloromonofluoromethane | ND | 0.39[a] | 0.44 | ND | ND | -- | -- | -- | -- |

**NOTES:**

**µg/m³** = micrograms per cubic metre

**ND** - not determined
**Low MQ** – Match quality was lower than 50%. Match quality quantifies the confidence with which the organic compound was identified. All data with match quality lower than 50% were removed.
**a** – Data Match quality higher than 50% but lower than 80%.
Odour threshold source

**1** *Odor thresholds and limitations levels of several chemical substances: A review.* Published by American industrial hygiene association and the 3M 2001 respirator selection guide.

**2** Nagata Y., *Measurement of Odor Threshold by Triangle Odor Bag Method*, Bulletin of Japan Environmental Sanitation Center, (1990), 17, pp. 77-89. On http://www.odour.cz/english/thresholds/thresholds.html

# *Appendix A*

Monitoring Data

**Table A1: Median one-hour air concentrations for each monitoring site in the Whitecourt sludge spreading area.**

| | Monitoring Location | $NH_3$ | $O_3$ | CO | Hydrocarbons | | | | Oxides of Nitrogen | | | Particulates | | | Sulphur Compounds | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $CH_4$ | RHC | THC | PAH | $NO_2$ | NO | $NO_x$ | $PM_{2.5}$ | $PM_{10}$ | TSP | $H_2S$ | TRS | $SO_2$ |
| | | ppm | ppm | ppm | ppm | ppm | ppm | ng/m³ | ppm | ppm | ppm | µg/m³ | µg/m³ | µg/m³ | ppm | ppm | ppm |
| 1 | **Access Road** to sludge spreading area | 0.022 | 0.027 | 0.1 | 2.1 | bd | 2.1 | 2 | 0.003 | 0.002 | 0.004 | 2 | 16 | 28 | 0.001 | 0.001 | 0.001 |
| 2 | 2km **downwind** of loading area | 0.004 | 0.033 | 0.2 | 2.0 | bd | 2.0 | bd | 0.001 | bd | 0.001 | 1 | 7 | 10 | 0.001 | bd | 0.001 |
| 3 | **Flats Road** near new sludge spreading area | 0.426 | 0.021 | 0.2 | 2.1 | bd | 2.1 | 1 | 0.005 | 0.004 | 0.010 | 2 | 23 | 43 | 0.003 | 0.002 | 0.001 |

**Table A2: Maximum air concentrations for each monitoring site in the Whitecourt sludge spreading area.**

| | Monitoring Location | $NH_3$ | $O_3$ | CO | Hydrocarbons | | | | Oxides of Nitrogen | | | Particulates | | | Sulphur Compounds | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $CH_4$ | RHC | THC | PAH | $NO_2$ | NO | $NO_x$ | $PM_{2.5}$ | $PM_{10}$ | TSP | $H_2S$ | TRS | $SO_2$ |
| | | ppm | ppm | ppm | ppm | ppm | ppm | ng/m³ | ppm | ppm | ppm | µg/m³ | µg/m³ | µg/m³ | ppm | ppm | ppm |
| 1 | **Access Road** to sludge spreading area | 0.315 | 0.037 | 1.8 | 6.1 | 0.2 | 6.6 | 111 | 0.158 | 0.071 | 0.172 | 47 | 924 | 2356 | 0.024 | 0.009 | 0.013 |
| 2 | 2km **downwind** of loading area | 0.015 | 0.037 | 0.8 | 2.6 | bd | 2.5 | 1 | 0.01 | 0.009 | 0.01 | 3 | 34 | 55 | 0.001 | 0.001 | 0.004 |
| 3 | **Flats Road** near new sludge spreading area | 1.203 | 0.036 | 1.6 | 3.5 | 0.3 | 3.7 | 11 | 0.05 | 0.034 | 0.056 | 57 | 1222 | 1642 | 0.008 | 0.005 | 0.015 |

**NOTES:**

**ppm** - parts per million

**ng/m³** = nanograms per cubic metre

**µg/m³** = micrograms per cubic metre

**ND** – not determined (analyzer not functioning)
**bd** – below detection limit of analyzer

**Table A1: Median one-hour air concentrations for each monitoring site in the Whitecourt sludge spreading area.**

| | Monitoring Location | $NH_3$ | $O_3$ | CO | Hydrocarbons | | | | Oxides of Nitrogen | | | Particulates | | | Sulphur Compounds | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $CH_4$ | RHC | THC | PAH | $NO_2$ | NO | $NO_x$ | $PM_{2.5}$ | $PM_{10}$ | TSP | $H_2S$ | TRS | $SO_2$ |
| | | ppm | ppm | ppm | ppm | ppm | ppm | $ng/m^3$ | ppm | ppm | ppm | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ | ppm | ppm | ppm |
| 1 | **Access Road** to sludge spreading area | 0.022 | 0.027 | 0.1 | 2.1 | bd | 2.1 | 2 | 0.003 | 0.002 | 0.004 | 2 | 16 | 28 | 0.001 | 0.001 | 0.001 |
| 2 | 2km **downwind** of loading area | 0.004 | 0.033 | 0.2 | 2.0 | bd | 2.0 | bd | 0.001 | bd | 0.001 | 1 | 7 | 10 | 0.001 | bd | 0.001 |
| 3 | **Flats Road** near new sludge spreading area | 0.426 | 0.021 | 0.2 | 2.1 | bd | 2.1 | 1 | 0.005 | 0.004 | 0.010 | 2 | 23 | 43 | 0.003 | 0.002 | 0.001 |

**Table A2: Maximum air concentrations for each monitoring site in the Whitecourt sludge spreading area.**

| | Monitoring Location | $NH_3$ | $O_3$ | CO | Hydrocarbons | | | | Oxides of Nitrogen | | | Particulates | | | Sulphur Compounds | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $CH_4$ | RHC | THC | PAH | $NO_2$ | NO | $NO_x$ | $PM_{2.5}$ | $PM_{10}$ | TSP | $H_2S$ | TRS | $SO_2$ |
| | | ppm | ppm | ppm | ppm | ppm | ppm | $ng/m^3$ | ppm | ppm | ppm | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ | ppm | ppm | ppm |
| 1 | **Access Road** to sludge spreading area | 0.315 | 0.037 | 1.8 | 6.1 | 0.2 | 6.6 | 111 | 0.158 | 0.071 | 0.172 | 47 | 924 | 2356 | 0.024 | 0.009 | 0.013 |
| 2 | 2km **downwind** of loading area | 0.015 | 0.037 | 0.8 | 2.6 | bd | 2.5 | 1 | 0.01 | 0.009 | 0.01 | 3 | 34 | 55 | 0.001 | 0.001 | 0.004 |
| 3 | **Flats Road** near new sludge spreading area | 1.203 | 0.036 | 1.6 | 3.5 | 0.3 | 3.7 | 11 | 0.05 | 0.034 | 0.056 | 57 | 1222 | 1642 | 0.008 | 0.005 | 0.015 |

**NOTES:**

**ppm** - parts per million

**$ng/m^3$** = nanograms per cubic metre

**$\mu g/m^3$** = micrograms per cubic metre

**ND** - not determined (analyzer not functioning)
**bd** - below detection limit of analyzer

*Intentionally Blank*

**Table A3: Median one-hour air pollutant concentrations in Alberta.**

| Air Quality Station or Survey Name | Station or Survey Type | Monitoring Period | $NH_3$ ppm | $O_3$ ppm | CO ppm | $CH_4$ ppm | RHC ppm | THC ppm | PAH ng/m3 | $NO_2$ ppm | TSP µg/m3 | $PM_{10}$ µg/m3 | $PM_{2.5}$ µg/m3 | $H_2S$ ppm | TRS ppm | $SO_2$ ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Whitecourt (current survey) | mobile | Sep. 6 - 7, 2005 | 0.084 | 0.027 | 0.2 | 2.1 | bd | 2.1 | 1 | 0.002 | 28 | 16 | 2 | 0.001 | 0.001 | 0.001 |
| Lloydminster[1] | mobile | Jan. 2002 to Nov. 2004 | 0.001 | 0.030 | 0.2 | 2.2 | 0.2 | 2.5 | 3 | 0.006 | 19 | 13 | 2 | bd | 0.001 | 0.001 |
| Lakeland Area[1] | mobile | May 2003 to Sep. 2004 | 0.002 | 0.031 | 0.2 | 2.4 | 0.2 | 2.6 | bd | 0.002 | 14 | 9 | 1 | bd | bd | bd |
| Banff[1] | mobile | Nov. 19 - 23, 2003 | 0.004 | 0.018 | 0.5 | 2.5 | 0.2 | 2.7 | 11 | 0.008 | 7 | 5 | 1 | 0.001 | bd | bd |
| Fort Saskatchewan/Redwater[1] | mobile | May 2001 to Mar. 2002 | 0.001 | 0.029 | 0.3 | 2.1 | 0.1 | 2.1 | bd | 0.004 | 39 | 22 | 3 | bd | bd | 0.001 |
| Cold Lake/Bonnyville/Elk Point[1] | mobile | Mar. 2001 to Feb. 2002 | 0.000 | 0.031 | 0.2 | 1.9 | 0.1 | 2.1 | 1 | 0.003 | 16 | 10 | 2 | bd | 0.001 | bd |
| Whitecourt/Swan Hills/Shiningbank Lake[1] | mobile | Mar. 2001 to Jun. 2001 | 0.001 | 0.027 | 0.2 | 2.0 | 0.3 | 2.3 | 1 | 0.005 | 47 | 29 | 4 | bd | 0.001 | 0.004 |
| Wabumun[1] | mobile | Jul. 2000 to Sep. 2001 | 0.004 | 0.027 | 0.2 | 1.9 | 0.1 | 2.0 | 1 | 0.005 | 34 | 22 | 3 | bd | bd | 0.002 |
| Edmonton Whitemud Drive[1] | mobile | Jun. 2000 to Jul. 2001 | bd | 0.019 | 0.4 | 2.0 | 0.1 | 2.2 | 8 | 0.014 | 41 | 24 | 3 | bd | bd | 0.002 |
| **Permanent Continuous Monitoring Stations** | | | | | | | | | | | | | | | | |
| Beaverlodge[2] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.028 | n/a | n/a | n/a | n/a | n/a | 0.003 | n/a | n/a | 2 | n/a | n/a | bd |
| Calgary Central[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.014 | 0.4 | n/a | n/a | 2.0 | n/a | 0.022 | n/a | 19 | 4 | n/a | n/a | n/a |
| Calgary East[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.015 | 0.3 | n/a | n/a | 2.1 | n/a | 0.019 | n/a | n/a | 5 | bd | n/a | 0.001 |
| Calgary Northwest[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.022 | 0.3 | n/a | n/a | 2.0 | n/a | 0.012 | n/a | n/a | 3 | n/a | n/a | n/a |
| Edmonton Central[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.015 | 0.4 | n/a | n/a | 2.0 | n/a | 0.019 | n/a | n/a | 4 | n/a | n/a | n/a |
| Edmonton East[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.019 | 0.2 | n/a | n/a | 2.2 | n/a | 0.013 | n/a | n/a | 4 | bd | n/a | n/a |
| Edmonton South[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.01 | 0.2 | n/a | n/a | 1.9 | n/a | 0.016 | n/a | n/a | 3 | n/a | n/a | n/a |
| Fort Saskatchewan[2] | small urban | Jan. 2005 to Dec. 2005 | 0.001 | 0.02 | 0.2 | n/a | n/a | 1.9 | n/a | 0.006 | n/a | n/a | 3 | bd | n/a | 0.001 |
| Red Deer[2] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.02 | 0.2 | n/a | n/a | 2.0 | n/a | 0.01 | n/a | n/a | 3 | bd | n/a | bd |
| Buffalo Viewpoint[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 1.9 | n/a | n/a | n/a | n/a | n/a | bd | n/a | bd |
| Fort Chipewyan[1] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.026 | n/a | n/a | n/a | n/a | n/a | bd | n/a | n/a | 1 | n/a | n/a | bd |
| Fort McKay[3] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.019 | n/a | n/a | n/a | 1.9 | n/a | 0.002 | n/a | n/a | 2 | n/a | bd | bd |
| Fort McMurray (Athabasca Valley)[3] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.017 | 0.2 | n/a | n/a | 2.0 | n/a | 0.007 | n/a | n/a | 2 | n/a | bd | bd |
| Fort McMurray (Patricia McInnes)[3] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.019 | n/a | n/a | n/a | 1.9 | n/a | 0.004 | n/a | n/a | 2 | n/a | bd | bd |
| Mannix[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 1.9 | n/a | n/a | n/a | n/a | n/a | bd | n/a | 0.001 |
| Mildred Lake[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 1.8 | n/a | n/a | n/a | n/a | n/a | bd | n/a | bd |
| Carrot Creek[3] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.025 | n/a | n/a | n/a | n/a | n/a | 0.005 | n/a | n/a | n/a | n/a | n/a | bd |
| Tomahawk[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.029 | n/a | n/a | n/a | n/a | n/a | 0.003 | n/a | n/a | 3 | n/a | n/a | 0.001 |
| Violet Grove[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.03 | n/a | n/a | n/a | 2.0 | n/a | 0.003 | n/a | n/a | n/a | n/a | n/a | 0.001 |
| Caroline[5] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.033 | n/a | n/a | n/a | 2.0 | n/a | n/a | n/a | n/a | n/a | n/a | bd | bd |

**NOTES:**

1 - Mobile survey conducted using Alberta Environment's MAML.
2 - Station operated by Alberta Environment.
3 - Station operated by the Wood Buffalo Environmental Association.
4 - Station operated by the West Central Airshed Society.
5 - Station operated by the Strathcona Industrial Association.
6 - Station operated by the Parkland Airshed Management Association.

**ppm** - parts per million **ng/m³** = nanograms per cubic metre **µg/m³** = micrograms per cubic metre

**n/a** - Parameter not monitored or data not available.
**bd** - Below lower detection limit of analyzer

**Table A3: Median one-hour air pollutant concentrations in Alberta.**

| Air Quality Station or Survey Name | Station or Survey Type | Monitoring Period | $NH_3$ ppm | $O_3$ ppm | CO ppm | $CH_4$ ppm | RHC ppm | THC ppm | PAH ng/m3 | $NO_2$ ppm | TSP µg/m3 | $PM_{10}$ µg/m3 | $PM_{2.5}$ µg/m3 | $H_2S$ ppm | TRS ppm | $SO_2$ ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Whitecourt (current survey)[1] | mobile | Sep. 6 - 7, 2005 | 0.064 | 0.027 | 0.2 | 2.1 | bd | 2.1 | 1 | 0.002 | 26 | 16 | 2 | 0.001 | 0.001 | 0.001 |
| Lloydminster[1] | mobile | Jan. 2002 to Nov. 2004 | 0.001 | 0.030 | 0.2 | 2.2 | 0.2 | 2.5 | 3 | 0.006 | 19 | 13 | 2 | bd | 0.001 | 0.001 |
| Lakeland Area[1] | mobile | May 2003 to Sep. 2004 | 0.002 | 0.031 | 0.2 | 2.4 | 0.2 | 2.6 | bd | 0.002 | 14 | 9 | 1 | bd | bd | bd |
| Banff[1] | mobile | Nov. 19 - 23, 2003 | 0.004 | 0.018 | 0.5 | 2.5 | 0.2 | 2.7 | 11 | 0.008 | 7 | 5 | 1 | 0.001 | bd | bd |
| Fort Saskatchewan/Redwater[1] | mobile | May 2001 to Mar. 2002 | 0.001 | 0.029 | 0.3 | 2.1 | 0.1 | 2.1 | bd | 0.004 | 39 | 22 | 3 | bd | bd | 0.001 |
| Cold Lake/Bonnyville/Elk Point[1] | mobile | Mar. 2001 to Feb. 2002 | 0.000 | 0.031 | 0.2 | 1.9 | 0.1 | 2.1 | 1 | 0.003 | 16 | 10 | 2 | bd | 0.001 | bd |
| Whitecourt/Swan Hills/Shiningbank Lake[1] | mobile | Mar. 2001 to Jun. 2001 | 0.001 | 0.027 | 0.2 | 2.0 | 0.3 | 2.3 | 1 | 0.005 | 47 | 29 | 4 | bd | 0.001 | 0.004 |
| Wabamun[1] | mobile | Jul. 2000 to Sep. 2001 | 0.004 | 0.027 | 0.2 | 1.9 | 0.1 | 2.0 | 1 | 0.005 | 34 | 22 | 3 | bd | bd | 0.002 |
| Edmonton Whitemud Drive[1] | mobile | Jun. 2000 to Jul. 2001 | bd | 0.019 | 0.4 | 2.0 | 0.1 | 2.2 | 8 | 0.014 | 41 | 24 | 3 | bd | bd | 0.002 |
| **Permanent Continuous Monitoring Stations** | | | | | | | | | | | | | | | | |
| Beaverlodge[2] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.028 | n/a | n/a | n/a | n/a | n/a | 0.003 | n/a | n/a | 2 | n/a | n/a | bd |
| Calgary Central[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.014 | 0.4 | n/a | n/a | 2.0 | n/a | 0.022 | n/a | 19 | 4 | n/a | n/a | n/a |
| Calgary East[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.015 | 0.3 | n/a | n/a | 2.1 | n/a | 0.019 | n/a | n/a | 5 | bd | n/a | 0.001 |
| Calgary Northwest[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.022 | 0.3 | n/a | n/a | 2.0 | n/a | 0.012 | n/a | n/a | 3 | n/a | n/a | n/a |
| Edmonton Central[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.015 | 0.4 | n/a | n/a | 2.0 | n/a | 0.019 | n/a | n/a | 4 | n/a | n/a | n/a |
| Edmonton East[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.019 | 0.2 | n/a | n/a | 2.2 | n/a | 0.013 | n/a | n/a | 4 | bd | n/a | n/a |
| Edmonton South[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.01 | 0.2 | n/a | n/a | 1.9 | n/a | 0.016 | n/a | n/a | 3 | n/a | n/a | n/a |
| Fort Saskatchewan[2] | small urban | Jan. 2005 to Dec. 2005 | 0.001 | 0.02 | 0.2 | n/a | n/a | 1.9 | n/a | 0.008 | n/a | n/a | 3 | bd | n/a | 0.001 |
| Red Deer[2] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.02 | 0.2 | n/a | n/a | 2.0 | n/a | 0.01 | n/a | n/a | 3 | bd | n/a | bd |
| Buffalo Viewpoint[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 1.9 | n/a | n/a | n/a | n/a | n/a | bd | n/a | bd |
| Fort Chipewyan[3] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.026 | n/a | n/a | n/a | n/a | n/a | bd | n/a | n/a | 1 | n/a | n/a | bd |
| Fort McKay[3] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.019 | n/a | n/a | n/a | 1.9 | n/a | 0.002 | n/a | n/a | 2 | n/a | bd | bd |
| Fort McMurray (Athabasca Valley)[3] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.017 | 0.2 | n/a | n/a | 2.0 | n/a | 0.007 | n/a | n/a | 2 | n/a | bd | bd |
| Fort McMurray (Patricia McInnes)[3] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.019 | n/a | n/a | n/a | 1.9 | n/a | 0.004 | n/a | n/a | 2 | n/a | bd | bd |
| Mannix[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 1.9 | n/a | n/a | n/a | n/a | n/a | bd | n/a | 0.001 |
| Mildred Lake[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 1.8 | n/a | n/a | n/a | n/a | n/a | bd | n/a | bd |
| Carrot Creek[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.025 | n/a | n/a | n/a | n/a | n/a | 0.005 | n/a | n/a | n/a | n/a | n/a | bd |
| Tomahawk[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.029 | n/a | n/a | n/a | n/a | n/a | 0.003 | n/a | n/a | 3 | n/a | n/a | 0.001 |
| Violet Grove[5] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.03 | n/a | n/a | n/a | 2.0 | n/a | 0.003 | n/a | n/a | n/a | n/a | n/a | 0.001 |
| Caroline[6] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.033 | n/a | n/a | n/a | 2.0 | n/a | n/a | n/a | n/a | n/a | n/a | bd | bd |

**NOTES:**

1 - Mobile survey conducted using Alberta Environment's MAML.
2 - Station operated by Alberta Environment.
3 - Station operated by the Wood Buffalo Environmental Association.
4 - Station operated by the West Central Airshed Society.
5 - Station operated by the Strathcona Industrial Association.
6 - Station operated by the Parkland Airshed Management Association.

**ppm** - parts per million **ng/m³** = nanograms per cubic metre **µg/m³** = micrograms per cubic metre

**n/a** - Parameter not monitored or data not available.
**bd** - Below lower detection limit of analyzer

**Table A4: Maximum* air pollutant concentrations in Alberta.**

| Air Quality Station or Survey Name | Station or Survey Type | Monitoring Period | $NH_3$ ppm | $O_3$ ppm | CO ppm | $CH_4$ ppm | RHC ppm | THC ppm | PAH $ng/m^3$ | $NO_2$ ppm | TSP $\mu g/m^3$ | $PM_{10}$ $\mu g/m^3$ | $PM_{2.5}$ $\mu g/m^3$ | $H_2S$ ppm | TRS ppm | $SO_2$ ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Whitecourt (current survey) | mobile | Sep. 6 - 7, 2005 | 1.203 | 0.037 | 1.8 | 6.1 | 0.3 | 6.6 | 111 | 0.071 | 2356 | 1222 | 57 | 0.024 | 0.009 | 0.015 |
| Lloydminster[1] | mobile | Jan. 2002 to Nov. 2004 | 0.016 | 0.043 | 0.8 | 4.9 | 2.9 | 5.2 | 27 | 0.038 | 1418 | 946 | 151 | 0.020 | 0.022 | 0.023 |
| Lakeland Area[1] | mobile | May 2003 to Sep. 2004 | 0.013 | 0.049 | 0.9 | 4.1 | 4.6 | 7.2 | 14 | 0.012 | 1505 | 1074 | 127 | 0.003 | 0.003 | 0.009 |
| Banff[1] | mobile | Nov. 19 - 23, 2003 | 0.013 | 0.034 | 1.5 | 3.1 | 0.6 | 3.8 | 105 | 0.003 | 37 | 23 | 21 | 0.003 | 0.001 | 0.002 |
| Fort Saskatchewan/Redwater[1] | mobile | May 2001 to Mar. 2002 | 0.577 | 0.049 | 2.2 | 3.6 | 0.5 | 3.6 | 70 | 0.051 | 547 | 323 | 24 | 0.003 | 0.004 | 0.022 |
| Cold Lake/Bonnyville/Elk Point[1] | mobile | Mar. 2001 to Feb. 2002 | 0.005 | 0.047 | 1.4 | 4.6 | 7.1 | 9.7 | 14 | 0.014 | 2281 | 1188 | 72 | 0.054 | 0.056 | 0.017 |
| Whitecourt/Swan Hills/Shiningbank Lake[1] | mobile | Mar. 2001 to Jun. 2001 | 0.013 | 0.054 | 0.7 | 2.5 | 2.5 | 4.3 | 113 | 0.030 | 946 | 441 | 43 | 0.003 | 0.005 | 0.046 |
| Wabumun[1] | mobile | Jul. 2000 to Sep. 2001 | 0.020 | 0.057 | 0.5 | 3.2 | 0.5 | 3.3 | 11 | 0.015 | 807 | 534 | 42 | 0.001 | 0.003 | 0.032 |
| Edmonton Whitemud Drive[1] | mobile | Jun. 2000 to Jul. 2001 | 0.039 | 0.059 | 2.7 | 2.7 | 1.6 | 4.4 | 77 | 0.041 | 459 | 239 | 37 | 0.003 | 0.005 | 0.015 |
| **Permanent Continuous Monitoring Stations** | | | | | | | | | | | | | | | | |
| Beaverlodge[2] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.061 | n/a | n/a | n/a | n/a | n/a | 0.036 | n/a | n/a | n/a | n/a | n/a | 0.028 |
| Calgary Central[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.055 | 8 | n/a | n/a | 4.9 | n/a | 0.097 | n/a | 241 | 51 | n/a | n/a | n/a |
| Calgary East[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.056 | 7.2 | n/a | n/a | n/a | n/a | 0.198 | n/a | n/a | 136 | 0.021 | 7.200 | 0.017 |
| Calgary Northwest[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.059 | 3.4 | n/a | n/a | 3.4 | n/a | 0.064 | n/a | n/a | 44 | n/a | n/a | n/a |
| Edmonton Central[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.062 | 6 | n/a | n/a | 4.9 | n/a | 0.074 | n/a | n/a | 49 | n/a | n/a | n/a |
| Edmonton East[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.058 | 8.8 | n/a | n/a | 14.4 | n/a | 0.098 | n/a | n/a | 64 | 0.018 | n/a | n/a |
| Edmonton South[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.042 | 3.3 | n/a | n/a | 5.3 | n/a | 0.058 | n/a | n/a | 41 | n/a | n/a | n/a |
| Fort Saskatchewan[2] | small-urban | Jan. 2005 to Dec. 2005 | 0.536 | 0.063 | 2.6 | n/a | n/a | 6.9 | n/a | 0.068 | n/a | n/a | 65 | 0.004 | n/a | 0.022 |
| Red Deer[2] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.067 | 2.5 | n/a | n/a | 7.7 | n/a | 0.058 | n/a | n/a | 39 | 0.009 | n/a | 0.008 |
| Buffalo Viewpoint[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 4.7 | n/a | n/a | n/a | n/a | n/a | 0.027 | n/a | 0.187 |
| Fort Chipewyan[3] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.053 | n/a | n/a | n/a | n/a | n/a | 0.03 | n/a | n/a | 97 | n/a | n/a | 0.019 |
| Fort McKay[3] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.062 | n/a | n/a | n/a | 5.5 | n/a | 0.053 | n/a | n/a | 73 | n/a | 0.017 | 0.126 |
| Fort McMurray (Athabasca Valley)[3] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.067 | 6.2 | n/a | n/a | 6.7 | n/a | 0.058 | n/a | n/a | 121 | n/a | 0.007 | 0.070 |
| Fort McMurray (Patricia McInnes)[3] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.059 | n/a | n/a | n/a | 3.6 | n/a | 0.044 | n/a | n/a | 59 | n/a | 0.007 | 0.151 |
| Mannix[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 9 | n/a | n/a | n/a | n/a | n/a | 0.021 | n/a | 0.178 |
| Mildred Lake[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 6.8 | n/a | n/a | n/a | n/a | n/a | 0.041 | n/a | 0.147 |
| Carrot Creek[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.066 | n/a | n/a | n/a | n/a | n/a | 0.049 | n/a | n/a | n/a | n/a | n/a | 0.013 |
| Tomahawk[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.066 | n/a | n/a | n/a | n/a | n/a | 0.031 | n/a | n/a | 244 | n/a | n/a | 0.029 |
| Violet Grove[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.07 | n/a | n/a | n/a | 9 | n/a | 0.03 | n/a | n/a | n/a | n/a | n/a | 0.026 |
| Caroline[5] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.083 | n/a | n/a | n/a | 9.6 | n/a | n/a | n/a | n/a | n/a | n/a | 0.006 | 0.025 |

**NOTES:**

* – Maximum concentrations for MAML measurements are calculated using one-minute averages. Maximum concentrations for permanent monitoring stations are calculated using one-hour averages.

1 – Mobile survey conducted by Alberta Environment.
2 – Station operated by Alberta Environment.
3 – Station operated by the Wood Buffalo Environmental Association.
4 – Station operated by the West Central Airshed Society.
5 – Station operated by the Strathcona Industrial Association.
6 – Station operated by the Parkland Airshed Management Association.

**ppm** – parts per million **$ng/m^3$** – nanograms per cubic metre **$\mu g/m^3$** – micrograms per cubic metre

**n/a** – Parameter not monitored or data not available.
**bd** – Below lower detection limit of analyzer

**Table A4: Maximum* air pollutant concentrations in Alberta.**

| Air Quality Station or Survey Name | Station or Survey Type | Monitoring Period | $NH_3$ ppm | $O_3$ ppm | CO ppm | $CH_4$ ppm | RHC ppm | THC ppm | PAH ng/m³ | $NO_2$ ppm | TSP µg/m³ | $PM_{10}$ µg/m³ | $PM_{2.5}$ µg/m³ | $H_2S$ ppm | TRS ppm | $SO_2$ ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Whitecourt (current survey) | mobile | Sep. 6 - 7, 2005 | 1.203 | 0.037 | 1.8 | 6.1 | 0.3 | 6.6 | 111 | 0.071 | 2356 | 1222 | 57 | 0.024 | 0.009 | 0.015 |
| Lloydminster[1] | mobile | Jan. 2002 to Nov. 2004 | 0.016 | 0.043 | 0.8 | 4.9 | 2.9 | 5.2 | 27 | 0.038 | 1418 | 946 | 151 | 0.020 | 0.022 | 0.023 |
| Lakeland Area[1] | mobile | May 2003 to Sep. 2004 | 0.013 | 0.049 | 0.9 | 4.1 | 4.6 | 7.2 | 14 | 0.012 | 1505 | 1074 | 127 | 0.003 | 0.003 | 0.009 |
| Banff[1] | mobile | Nov. 19 - 23, 2003 | 0.013 | 0.034 | 1.5 | 3.1 | 0.8 | 3.6 | 105 | 0.003 | 37 | 23 | 21 | 0.003 | 0.001 | 0.002 |
| Fort Saskatchewan/Redwater[1] | mobile | May 2001 to Mar. 2002 | 0.577 | 0.049 | 2.2 | 3.6 | 0.5 | 3.6 | 70 | 0.051 | 547 | 323 | 24 | 0.003 | 0.004 | 0.022 |
| Cold Lake/Bonnyville/Elk Point[1] | mobile | Mar. 2001 to Feb. 2002 | 0.005 | 0.047 | 1.4 | 4.6 | 7.1 | 9.7 | 14 | 0.014 | 2281 | 1188 | 72 | 0.054 | 0.056 | 0.017 |
| Whitecourt/Swan Hills/Shiningbank Lake[1] | mobile | Mar. 2001 to Jun. 2001 | 0.013 | 0.054 | 0.7 | 2.5 | 2.5 | 4.3 | 113 | 0.030 | 946 | 441 | 43 | 0.003 | 0.005 | 0.046 |
| Wabumun[1] | mobile | Jul. 2000 to Sep. 2001 | 0.020 | 0.057 | 0.5 | 3.2 | 0.5 | 3.3 | 11 | 0.015 | 807 | 534 | 42 | 0.001 | 0.003 | 0.032 |
| Edmonton Whitemud Drive[1] | mobile | Jun. 2000 to Jul. 2001 | 0.039 | 0.059 | 2.7 | 2.7 | 1.6 | 4.4 | 77 | 0.041 | 459 | 239 | 37 | 0.003 | 0.005 | 0.015 |
| **Permanent Continuous Monitoring Stations** | | | | | | | | | | | | | | | | |
| Beaverlodge[2] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.061 | n/a | n/a | n/a | n/a | n/a | 0.036 | n/a | n/a | n/a | n/a | n/a | 0.028 |
| Calgary Central[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.055 | 8 | n/a | n/a | 4.9 | n/a | 0.097 | n/a | 241 | 51 | n/a | n/a | n/a |
| Calgary East[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.056 | 7.2 | n/a | n/a | n/a | n/a | 0.196 | n/a | n/a | 136 | 0.021 | 7.200 | 0.017 |
| Calgary Northwest[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.059 | 3.4 | n/a | n/a | 3.4 | n/a | 0.064 | n/a | n/a | 44 | n/a | n/a | n/a |
| Edmonton Central[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.052 | 6 | n/a | n/a | 4.9 | n/a | 0.074 | n/a | n/a | 49 | n/a | n/a | n/a |
| Edmonton East[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.058 | 8.8 | n/a | n/a | 14.4 | n/a | 0.098 | n/a | n/a | 64 | 0.018 | n/a | n/a |
| Edmonton South[2] | urban | Jan. 2005 to Dec. 2005 | n/a | 0.042 | 3.3 | n/a | n/a | 5.3 | n/a | 0.058 | n/a | n/a | 41 | n/a | n/a | n/a |
| Fort Saskatchewan[2] | small-urban | Jan. 2005 to Dec. 2005 | 0.536 | 0.063 | 2.6 | n/a | n/a | 6.9 | n/a | 0.068 | n/a | n/a | 65 | 0.004 | n/a | 0.022 |
| Red Deer[2] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.067 | 2.5 | n/a | n/a | 7.7 | n/a | 0.058 | n/a | n/a | 39 | 0.009 | n/a | 0.008 |
| Buffalo Viewpoint[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 4.7 | n/a | n/a | n/a | n/a | n/a | 0.027 | n/a | 0.187 |
| Fort Chipewyan[3] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.053 | n/a | n/a | n/a | n/a | n/a | 0.03 | n/a | n/a | 97 | n/a | n/a | 0.019 |
| Fort McKay[3] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.062 | n/a | n/a | n/a | 5.5 | n/a | 0.053 | n/a | n/a | 73 | n/a | 0.017 | 0.126 |
| Fort McMurray (Athabasca Valley)[3] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.067 | 6.2 | n/a | n/a | 6.7 | n/a | 0.058 | n/a | n/a | 121 | n/a | 0.007 | 0.070 |
| Fort McMurray (Patricia McInnes)[3] | small urban | Jan. 2005 to Dec. 2005 | n/a | 0.059 | n/a | n/a | n/a | 3.6 | n/a | 0.044 | n/a | n/a | 59 | n/a | 0.007 | 0.151 |
| Mannix[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 9 | n/a | n/a | n/a | n/a | n/a | 0.021 | n/a | 0.178 |
| Mildred Lake[3] | industrial | Jan. 2005 to Dec. 2005 | n/a | n/a | n/a | n/a | n/a | 6.8 | n/a | n/a | n/a | n/a | n/a | 0.041 | n/a | 0.147 |
| Carrot Creek[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.066 | n/a | n/a | n/a | n/a | n/a | 0.049 | n/a | n/a | n/a | n/a | n/a | 0.013 |
| Tomahawk[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.066 | n/a | n/a | n/a | n/a | n/a | 0.031 | n/a | n/a | 244 | n/a | n/a | 0.029 |
| Violet Grove[4] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.07 | n/a | n/a | n/a | 9 | n/a | 0.03 | n/a | n/a | n/a | n/a | n/a | 0.026 |
| Caroline[5] | rural | Jan. 2005 to Dec. 2005 | n/a | 0.083 | n/a | n/a | n/a | 9.6 | n/a | n/a | n/a | n/a | n/a | n/a | 0.006 | 0.025 |

**NOTES:**

* – Maximum concentrations for MAML measurements are calculated using one-minute averages. Maximum concentrations for permanent monitoring stations are calculated using one-hour averages.

1 – Mobile survey conducted by Alberta Environment.
2 – Station operated by Alberta Environment.
3 – Station operated by the Wood Buffalo Environmental Association.
4 – Station operated by the West Central Airshed Society.
5 – Station operated by the Strathcona Industrial Association.
6 – Station operated by the Parkland Airshed Management Association.

**ppm** – parts per million **ng/m³** – nanograms per cubic metre **µg/m³** – micrograms per cubic metre

**n/a** – Parameter not monitored or data not available.
**bd** – Below lower detection limit of analyzer

**Table A5: Chronological listing of one-hour average concentrations (by site).**

| Site | Date | Time (MST) | $NH_3$ PPM | CO PPM | $O_3$ PPM | $CH_4$ PPM | RHC PPM | THC PPM | PAH ng/m³ | $NO_2$ PPM | NO PPM | $NO_x$ PPM | TSP µg/m³ | $PM_{10}$ µgr/m³ | $PM_{2.5}$ µgr/m³ | H2S PPM | TRS PPM | $SO_2$ PPM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Access Road | 6-Sep-05 | 10:28 to 11:28 | 0.001 | 0.2 | 0.016 | 2.1 | bd | 2.1 | 2 | 0.003 | 0.006 | 0.008 | 112 | 54 | 4 | 0.001 | 0.001 | 0.006 |
| | 6-Sep-05 | 11:28 to 12:28 | 0.017 | 0.1 | 0.027 | 2.0 | bd | 2.0 | 3 | 0.002 | 0.003 | 0.004 | 28 | 16 | 2 | 0.001 | 0.001 | 0.002 |
| | 6-Sep-05 | 12:28 to 13:28 | 0.022 | 0.1 | 0.030 | 2.0 | bd | 2.0 | bd | 0.001 | 0.002 | 0.001 | 21 | 12 | 1 | bd | bd | 0.001 |
| | 6-Sep-05 | 15:02 to 16:02 | 0.090 | 0.1 | 0.034 | 2.0 | bd | 2.0 | bd | 0.001 | 0.001 | 0.003 | 19 | 11 | 1 | 0.001 | 0.001 | 0.001 |
| | 7-Sep-05 | 07:27 to 08:27 | 0.084 | 0.2 | 0.003 | 2.8 | bd | 2.8 | 5.2 | 0.007 | 0.018 | 0.025 | 128 | 71 | 9 | 0.002 | 0.002 | 0.000 |
| 2 km **downwind** of Spreading Area | 6-Sep-05 | 13:42 to 14:48 | 0.004 | 0.2 | 0.033 | 2.0 | bd | 2.0 | bd | 0.000 | 0.001 | 0.001 | 10 | 7 | 1 | 0.001 | 0.001 | 0.001 |
| **Flats Road** Near Newer Pile Location | 6-Sep-05 | 16:39 to 17:39 | 0.426 | 0.0 | 0.032 | 2.1 | bd | 2.1 | 1 | 0.002 | 0.003 | 0.005 | 58 | 36 | 3 | 0.003 | 0.003 | 0.002 |
| | 6-Sep-05 | 17:39 to 18:39 | 0.823 | 0.2 | 0.021 | 2.3 | 0.1 | 2.4 | 2 | 0.006 | 0.008 | 0.016 | 43 | 23 | 2 | 0.004 | 0.004 | 0.001 |
| | 6-Sep-05 | 18:39 to 19:39 | 0.279 | 0.2 | 0.015 | 2.1 | bd | 2.1 | 1 | 0.004 | 0.006 | 0.010 | 14 | 10 | 2 | 0.002 | 0.002 | 0.001 |

**NOTES:**

**ppm** - parts per million **ng/m³** = nanograms per cubic metre **µg/m³** = micrograms per cubic metre

**bd** – below detection limit of analyzer

**Table A5: Chronological listing of one-hour average concentrations (by site).**

| Site | Date | Time (MST) | $NH_3$ PPM | CO PPM | $O_3$ PPM | $CH_4$ PPM | RHC PPM | THC PPM | PAH ng/m³ | $NO_2$ PPM | NO PPM | $NO_x$ PPM | TSP µg/m³ | $PM_{10}$ µgr/m³ | $PM_{2.5}$ µgr/m³ | H2S PPM | TRS PPM | $SO_2$ PPM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Access Road | 6-Sep-05 | 10:28 to 11:28 | 0.001 | 0.2 | 0.016 | 2.1 | bd | 2.1 | 2 | 0.003 | 0.006 | 0.008 | 112 | 54 | 4 | 0.001 | 0.001 | 0.006 |
| | 6-Sep-05 | 11:28 to 12:28 | 0.017 | 0.1 | 0.027 | 2.0 | bd | 2.0 | 3 | 0.002 | 0.003 | 0.004 | 28 | 16 | 2 | 0.001 | 0.001 | 0.002 |
| | 6-Sep-05 | 12:28 to 13:28 | 0.022 | 0.1 | 0.030 | 2.0 | bd | 2.0 | bd | 0.001 | 0.002 | 0.001 | 21 | 12 | 1 | bd | bd | 0.001 |
| | 6-Sep-05 | 15:02 to 16:02 | 0.090 | 0.1 | 0.034 | 2.0 | bd | 2.0 | bd | 0.001 | 0.001 | 0.003 | 19 | 11 | 1 | 0.001 | 0.001 | 0.001 |
| | 7-Sep-05 | 07:27 to 08:27 | 0.084 | 0.2 | 0.003 | 2.6 | bd | 2.6 | 5.2 | 0.007 | 0.024 | 0.025 | 128 | 71 | 9 | 0.002 | 0.002 | 0.000 |
| 2 km **downwind** of Spreading Area | 6-Sep-05 | 13:42 to 14:48 | 0.004 | 0.2 | 0.033 | 2.0 | bd | 2.0 | bd | 0.000 | 0.001 | 0.001 | 10 | 7 | 1 | 0.001 | 0.001 | 0.001 |
| **Flats Road** Near Newer Pile Location | 6-Sep-05 | 16:39 to 17:39 | 0.426 | 0.0 | 0.032 | 2.1 | bd | 2.1 | 1 | 0.002 | 0.002 | 0.005 | 58 | 36 | 3 | 0.003 | 0.003 | 0.002 |
| | 6-Sep-05 | 17:39 to 18:39 | 0.823 | 0.2 | 0.021 | 2.3 | 0.1 | 2.4 | 2 | 0.006 | 0.008 | 0.016 | 43 | 23 | 2 | 0.004 | 0.004 | 0.001 |
| | 6-Sep-05 | 18:39 to 19:39 | 0.279 | 0.2 | 0.015 | 2.1 | bd | 2.1 | 1 | 0.004 | 0.005 | 0.010 | 14 | 10 | 2 | 0.002 | 0.002 | 0.001 |

**NOTES:**

**ppm** - parts per million **ng/m³** = nanograms per cubic metre **µg/m³** = micrograms per cubic metre

**bd** – below detection limit of analyzer

**Table A5: Weather conditions and operator comments.**

| Site | Date | Time (MST) | Comments | Temp °C | RH % | WSP KPH | WDR DEG |
|---|---|---|---|---|---|---|---|
| Access Road | 6-Sep-05 | 10:28 to 11:28 | Close to loading area | 19.5 | 44.5 | 3.4 | 208 |
| | 6-Sep-05 | 11:28 to 12:28 | Manure odours evident | 19.2 | 37.4 | 6.9 | 249 |
| | 6-Sep-05 | 12:28 to 13:28 | | 19.3 | 36.7 | 7.9 | 267 |
| | 6-Sep-05 | 15:02 to 16:02 | Strong odours from spreading | 22.6 | 29.7 | 6.4 | 252 |
| | 7-Sep-05 | 07:27 to 08:27 | | 5.7 | 94.9 | 11.0 | 269 |
| 2 km **downwind** of Spreading Area | 6-Sep-05 | 13:42 to 14:48 | | 21.6 | 32.7 | 5.8 | 229 |
| **Flats Road** Near Newer Pile Location | 6-Sep-05 | 16:39 to 17:39 | Strong odour from newly spread sludge | 20.4 | 37.5 | 4.8 | 189 |
| | 6-Sep-05 | 17:39 to 18:39 | | 19.1 | 47.3 | 2.7 | 186 |
| | 6-Sep-05 | 18:39 to 19:39 | | 16.2 | 66.5 | 1.7 | 232 |

**NOTES:**
**Temp** - Temperature in degrees centigrade
**RH** – Relative humidity in percentage
**WSP KPH** – Wind speed in Km/hr
**WDR DEG** – Wind direction in degrees

**Table A5: Weather conditions and operator comments.**

| Site | Date | Time (MST) | Comments | Temp °C | RH % | WSP KPH | WDR DEG |
|---|---|---|---|---|---|---|---|
| Access Road | 6-Sep-05 | 10:28 to 11:28 | Close to loading area, | 19.5 | 44.5 | 3.4 | 208 |
| | 6-Sep-05 | 11:28 to 12:28 | Manure odours evident | 19.2 | 37.4 | 6.9 | 249 |
| | 6-Sep-05 | 12:28 to 13:28 | | 19.3 | 36.7 | 7.9 | 267 |
| | 6-Sep-05 | 15:02 to 16:02 | Strong odours from spreading | 22.6 | 29.7 | 6.4 | 252 |
| | 7-Sep-05 | 07:27 to 08:27 | | 5.7 | 94.9 | 11.0 | 268 |
| 2 km **downwind** of Spreading Area | 6-Sep-05 | 13:42 to 14:48 | | 21.6 | 32.7 | 5.8 | 229 |
| **Flats Road** Near Newer Pile Location | 6-Sep-05 | 16:39 to 17:39 | Strong odour from newly spread sludge | 20.4 | 37.5 | 4.8 | 189 |
| | 6-Sep-05 | 17:39 to 18:39 | | 19.1 | 47.3 | 2.7 | 186 |
| | 6-Sep-05 | 18:39 to 19:39 | | 16.2 | 66.5 | 1.7 | 232 |

**NOTES:**
**Temp** - Temperature in degrees centigrade
**RH** – Relative humidity in percentage
**WSP KPH** – Wind speed in Km/hr
**WDR DEG** – Wind direction in degrees

**Table A6 Volatile Organic Compounds (Canister Analysis Results)**

| Sample Site | VOC sample 1 | VOC sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 |
|---|---|---|---|---|---|
| Location of Sample | Background Sample: Lookout Point on Blue Ridge Road | Upwind Flats Road and Trestle Road | 300 m East of New Pile Loading, Flats Road | At Loading Operations; Access Road, 1.5 miles East of Trestle Road | 2 km downwind from Spreading Operations |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ |
| 1,1,1-Trichloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,1,2,2-Tetrachloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,1,2-Trichloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,1-Dichloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,1-Dichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2,4-Trichlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2,4-Trimethylbenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2-Dibromoethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2-Dichlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2-Dichloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2-Dichloropropane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,3,5-Trimethylbenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,3-Dichlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,4-Dichlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1-Butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1-Pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,2,4-Trimethylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,2-Dimethylbutane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,3,4-Trimethylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,3-Dimethylbutane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,3-Dimethylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,4-Dimethylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,5-dimethyl Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-ethyl Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-methyl Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methyl-1-pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methyl-2-butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methylheptane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methylhexane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Propanone | *1.37*[a] | *1.37*[a] | *1.27* | Low MQ | *2.80*[a] |
| 3-methyl Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Methyl-1-butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Methylheptane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Methylhexane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Methylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4-Methyl-1-pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| (E)-4-Octene | ND | *5.66*[a] | ND | ND | ND |

Continued ...

**Table A6** ... continued from previous page

| Sample Site | VOC sample 1 | VOC sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 |
|---|---|---|---|---|---|
| Location of Sample | Background Sample: Lookout Point on Blue Ridge Road | Upwind Flats Road and Trestle Road | 300 m East of New Pile Loading, Flats Road | At Loading Operations; Access Road, 1.5 mi East of Trestle Road | 2 km downwind from Spreading Operations |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ |
| α-p-dimethylstyrene | ND | *0.52* | ND | ND | ND |
| p-Cymene | ND | *4.71* | ND | ND | ND |
| Acetaldehyde | ND | Low MQ | Low MQ | ND | *2.67* |
| Acetic acid ethenyl ester | ND | ND | ND | ND | Low MQ |
| Allyl sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| α-Pinene | 0.00 | 0.00 | *0.18* | 0.00 | 0.00 |
| Benzene | *0.38* | *0.41* | *0.40* | *0.34* | *0.39* |
| β-Pinene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Bromomethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Butane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Butyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Butyl sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Carbon disulphide | 0.00 | *0.31* | 0.00 | 0.00 | 0.00 |
| Carbon tetrachloride | *0.48* | *0.44* | *0.44* | *0.47* | 0.00 |
| Carbonyl sulphide | *1.01* | *1.32* | *0.74* | *1.20* | *1.28* |
| Chlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chloroform | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chloromethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cis-1,2-Dichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | *0.21* |
| cis-1,3-Dichloropropylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cis-2-Butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cis-2-Hexene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cis-2-Pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cycloheptane | ND | Low MQ | ND | ND | ND |
| Cyclohexane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cyclopentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cyclopentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dimethyl disulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dimethyl sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dimethyl trisulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethyl benzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethyl sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Freon-11 | *0.73* | *0.71* | *0.72* | *0.67* | *0.65* |
| Freon-113 | *0.16* | 0.00 | 0.00 | *0.16* | 0.00 |
| Freon-114 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Freon-12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Continued ...

**Table A6 Volatile Organic Compounds (Canister Analysis Results)**

| Sample Site | VOC sample 1 | VOC sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 |
|---|---|---|---|---|---|
| Location of Sample | **Background** Sample: Lookout Point on Blue Ridge Road | **Upwind** Flats Road and Trestle Road | 300 m East of New Pile Loading, **Flats Road** | At Loading Operations; **Access Road**, 1.5 miles East of Trestle Road | 2 km **downwind** from Spreading Operations |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ |
| 1,1,1-Trichloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,1,2,2-Tetrachloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,1,2-Trichloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,1-Dichloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,1-Dichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2,4-Trichlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2,4-Trimethylbenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2-Dibromoethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2-Dichlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2-Dichloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,2-Dichloropropane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,3,5-Trimethylbenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,3-Dichlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1,4-Dichlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1-Butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1-Pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,2,4-Trimethylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,2-Dimethylbutane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,3,4-Trimethylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,3-Dimethylbutane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,3-Dimethylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,4-Dimethylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2,5-dimethyl Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-ethyl Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-methyl Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methyl-1-pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methyl-2-butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methylheptane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methylhexane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Methylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Propanone | *1.37*[a] | *1.37*[a] | *1.27* | Low MQ | *2.80*[a] |
| 3-methyl Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Methyl-1-butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Methylheptane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Methylhexane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Methylpentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4-Methyl-1-pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| (E)-4-Octene | ND | *5.66*[a] | ND | ND | ND |

Continued ...

**Table A6** **... continued from previous page**

| Sample Site | VOC sample 1 | VOC sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 |
|---|---|---|---|---|---|
| Location of Sample | **Background** Sample: Lookout Point on Blue Ridge Road | **Upwind** Flats Road and Trestle Road | 300 m East of New Pile Loading, **Flats Road** | At Loading Operations; **Access Road**, 1.5 mi East of Trestle Road | 2 km **downwind** from Spreading Operations |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ |
| α-p-dimethylstyrene | ND | ***0.52*** | ND | ND | ND |
| p-Cymene | ND | ***4.71*** | ND | ND | ND |
| Acetaldehyde | ND | Low MQ | Low MQ | ND | ***2.67*** |
| Acetic acid ethenyl ester | ND | ND | ND | ND | Low MQ |
| Allyl sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| α-Pinene | 0.00 | 0.00 | ***0.16*** | 0.00 | 0.00 |
| Benzene | ***0.38*** | ***0.41*** | ***0.40*** | ***0.34*** | ***0.39*** |
| β-Pinene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Bromomethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Butane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Butyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Butyl sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Carbon disulphide | 0.00 | ***0.31*** | 0.00 | 0.00 | 0.00 |
| Carbon tetrachloride | ***0.48*** | ***0.44*** | ***0.44*** | ***0.47*** | 0.00 |
| Carbonyl sulphide | ***1.01*** | ***1.32*** | ***0.74*** | ***1.20*** | ***1.28*** |
| Chlorobenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chloroethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chloroform | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chloromethane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cis-1,2-Dichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | ***0.21*** |
| cis-1,3-Dichloropropylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cis-2-Butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cis-2-Hexene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cis-2-Pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cycloheptane | ND | Low MQ | ND | ND | ND |
| Cyclohexane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cyclopentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cyclopentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dimethyl disulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dimethyl sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dimethyl trisulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethyl benzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethyl sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Freon-11 | ***0.73*** | ***0.71*** | ***0.72*** | ***0.67*** | ***0.65*** |
| Freon-113 | ***0.16*** | 0.00 | 0.00 | ***0.16*** | 0.00 |
| Freon-114 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Freon-12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Continued ...

**Table A6** **... continued from previous page**

| Sample Site | VOC sample 1 | VOC sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 |
|---|---|---|---|---|---|
| Location of Sample | **Background** Sample: Lookout Point on Blue Ridge Road | **Upwind** Flats Road and Trestle Road | 300 m East of New Pile Loading, Flats Road | At Loading Operations; Access Road, 1.5 mi East of Trestle Road | 2 km **downwind** from Spreading Operations |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ |
| Heptane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Heptyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hexachlorobutadiene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hexane | 0.00 | *0.21* | 0.00 | 0.00 | *0.11* |
| Hexyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hydrogen sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isobutane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isobutyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isopentane | *0.14* | *0.27* | *0.13* | *0.30* | *0.16* |
| Isoprene | *0.74* | *0.77* | 0.00 | *0.15* | *0.27* |
| Isopropyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isopropylbenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| m,p-Xylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Methyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Methylcyclohexane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Methylcyclopentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Methylene chloride | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nonane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| n-Propylbenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Octane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Octyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| o-Xylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pentyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Propyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sec-Butyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Styrene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sulphur dioxide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| tert-Butyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| tert-Pentyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tetrachloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Toluene | *0.11* | *0.12* | *2.63* | *0.56* | *0.12* |
| trans-1,2-Dichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| trans-1,3-Dichloropropylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| trans-2-Butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Continued ...

**Table A6** **... continued from previous page**

| Sample Site | VOC sample 1 | VOC sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 |
|---|---|---|---|---|---|
| Location of Sample | **Background** Sample: Lookout Point on Blue Ridge Road | **Upwind** Flats Road and Trestle Road | 300 m East of New Pile Loading, **Flats Road** | At Loading Operations, **Access Road**, 1.5 m East of Trestle Road | 2 km downwind from Spreading Operations |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ |
| trans-2-Hexene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| trans-2-Pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Trichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Trichloromonofluoromethane | ND | ***0.39***[a] | ***0.44*** | ND | ND |
| Vinyl chloride | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

***Bold and Italics*** – VOC concentration above the detection limit

**NOTES:**
**µg/m³** = micrograms per cubic metre
**ND** – not determined
**Low MQ** – Match quality was lower than 50%. Match quality quantifies the confidence with which the organic compound was identified. All data with match quality lower than 50% were removed.
**a** – Data Match quality higher than 50% but lower than 80%.

**Table A6** **... continued from previous page**

| Sample Site | VOC sample 1 | VOC sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 |
|---|---|---|---|---|---|
| Location of Sample | **Background** Sample: Lookout Point on Blue Ridge Road | **Upwind** Flats Road and Trestle Road | 300 m East of New Pile Loading, **Flats Road** | At Loading Operations; **Access Road**, 1.5 mi East of Trestle Road | 2 km **downwind** from Spreading Operations |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ |
| Heptane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Heptyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hexachlorobutadiene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hexane | 0.00 | ***0.21*** | 0.00 | 0.00 | ***0.11*** |
| Hexyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hydrogen sulphide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isobutane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isobutyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isopentane | ***0.14*** | ***0.27*** | ***0.13*** | ***0.30*** | ***0.16*** |
| Isoprene | ***0.74*** | ***0.77*** | 0.00 | ***0.15*** | ***0.27*** |
| Isopropyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isopropylbenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| m,p-Xylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Methyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Methylcyclohexane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Methylcyclopentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Methylene chloride | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nonane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| n-Propylbenzene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Octane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Octyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| o-Xylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pentane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pentyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Propyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sec-Butyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Styrene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sulphur dioxide | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| tert-Butyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| tert-Pentyl mercaptan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tetrachloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Thiophene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Toluene | ***0.11*** | ***0.12*** | ***2.63*** | ***0.56*** | ***0.12*** |
| trans-1,2-Dichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| trans-1,3-Dichloropropylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| trans-2-Butene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Continued ...

**Table A6** **... continued from previous page**

| Sample Site | VOC sample 1 | VOC sample 2 | VOC sample 3 | VOC sample 4 | VOC sample 5 |
|---|---|---|---|---|---|
| Location of Sample | **Background** Sample: Lookout Point on Blue Ridge Road | **Upwind** Flats Road and Trestle Road | 300 m East of New Pile Loading, **Flats Road** | At Loading Operations; **Access Road**, 1.5 mi East of Trestle Road | 2 km **downwind** from Spreading Operations |
| Sample Date | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 | 6-Sep-05 |
| Sample Duration | 15:53 to 16:53 | 17:31 to 18:31 | 15:30 to 16:30 | 11:41 to 12:41 | 12:58 to 13:58 |
| Units | µg/m³ | µg/m³ | µg/m³ | µg/m³ | µg/m³ |
| trans-2-Hexene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| trans-2-Pentene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Trichloroethylene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Trichloromonofluoromethane | ND | ***0.39***[a] | ***0.44*** | ND | ND |
| Vinyl chloride | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

***Bold and Italics*** – VOC concentration above the detection limit

**NOTES:**
**µg/m³** = micrograms per cubic metre
**ND** – not determined
**Low MQ** – Match quality was lower than 50%. Match quality quantifies the confidence with which the organic compound was identified. All data with match quality lower than 50% were removed.
**a** – Data Match quality higher than 50% but lower than 80%.

*Intentionally Blank*

# *Appendix B*

# *Alberta's Ambient Air Quality Objectives*

Alberta's Ambient Air Quality Objectives[1] are established under Section 14 of the Environmental Protection and Enhancement Act (EPEA R.S.A. 2000, c.E-12, as amended). EPEA provides for the development of environmental objectives for Alberta.
The Ambient Air Quality Objectives are used for:

- Reporting on the state of the atmospheric environment in Alberta.
- Reporting to Albertans on the quality of the air through Alberta's Air Quality Index (AQI).
- Establishing approval conditions for regulated industrial facilities.
- Evaluating proposals to construct facilities that will have air emissions.
- Guiding special ambient air quality surveys.
- Assessing compliance near major industrial air emission sources.

Some of Alberta's Ambient Air Quality Objectives are based on odour perception. This is the case for ammonia, nitrogen dioxide and hydrogen sulphide. For these chemicals, people are likely to detect an odour at concentrations well below levels that may affect human health. Alberta's Ambient Air Quality Objectives for one-hour average concentration of pollutants monitored by the MAML are listed in Table A8.

**Table A7: Alberta's Ambient Air Quality Objective measured by the MAML**

| Pollutant | One-hour AAAQO (ppm*) | Basis for Objective |
|---|---|---|
| Ammonia | 2 | odour perception |
| Carbon monoxide | 13 | oxygen carrying capacity of blood |
| Nitrogen dioxide | 0.212 | odour perception |
| Ozone | 0.082 | reduction of lung function and effects on vegetation |
| Hydrogen sulphide | 0.01 | odour perception |
| Sulphur dioxide | 0.172 | pulmonary function |

* **Parts per million by volume.**

[1] *Alberta Ambient Air Quality Objectives.* Alberta Environment. April 2005.

# *Alberta's Ambient Air Quality Objectives*

Alberta's Ambient Air Quality Objectives[1] are established under Section 14 of the Environmental Protection and Enhancement Act (EPEA R.S.A. 2000, c.E-12, as amended). EPEA provides for the development of environmental objectives for Alberta. The Ambient Air Quality Objectives are used for:

- Reporting on the state of the atmospheric environment in Alberta.
- Reporting to Albertans on the quality of the air through Alberta's Air Quality Index (AQI).
- Establishing approval conditions for regulated industrial facilities.
- Evaluating proposals to construct facilities that will have air emissions.
- Guiding special ambient air quality surveys.
- Assessing compliance near major industrial air emission sources.

Some of Alberta's Ambient Air Quality Objectives are based on odour perception. This is the case for ammonia, nitrogen dioxide and hydrogen sulphide. For these chemicals, people are likely to detect an odour at concentrations well below levels that may affect human health. Alberta's Ambient Air Quality Objectives for one-hour average concentration of pollutants monitored by the MAML are listed in Table A8.

**Table A7: Alberta's Ambient Air Quality Objective measured by the MAML**

| Pollutant | One-hour AAAQO (ppm*) | Basis for Objective |
|---|---|---|
| Ammonia | 2 | odour perception |
| Carbon monoxide | 13 | oxygen carrying capacity of blood |
| Nitrogen dioxide | 0.212 | odour perception |
| Ozone | 0.082 | reduction of lung function and effects on vegetation |
| Hydrogen sulphide | 0.01 | odour perception |
| Sulphur dioxide | 0.172 | pulmonary function |

* **Parts per million by volume.**

[1] *Alberta Ambient Air Quality Objectives.* Alberta Environment. April 2005.

## *The Mobile Air Monitoring Laboratory (MAML)*

The MAML is a 27-foot (8.2 m) vehicle that has been specially designed and equipped to measure air quality. It houses a variety of instruments that continuously sample the air at specified time or distance intervals. The MAML is equipped with:

- a dual computer system custom-programmed to accept and record the measurement of air samples from each analyser,
- a GPS (Global Positioning System) that identifies the MAML's location as it moves around Alberta,
- an exhaust purifying system that minimizes emissions from the vehicle and
- two on-board generators that are also equipped with exhaust scrubbers

Table A8 lists the pollutants and meteorological data monitored by the MAML. Also indicated are the lower and upper detection limits for each monitored species.

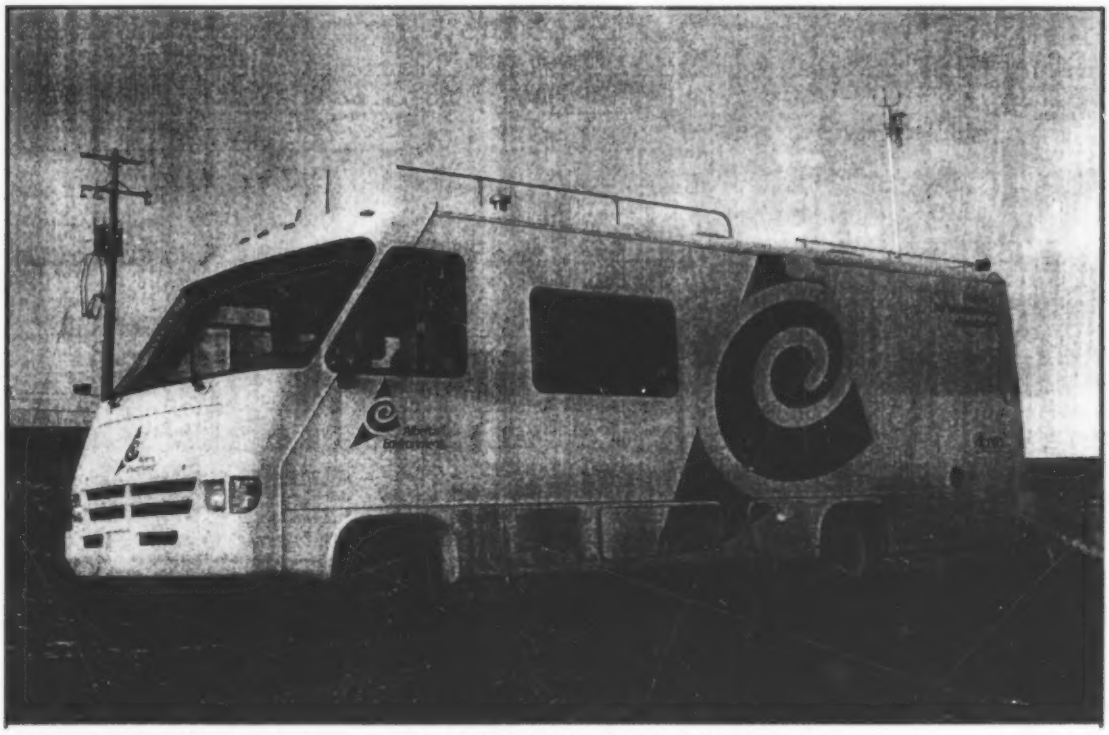


**Figure A1: Alberta Environment's Mobile Air Monitoring Laboratory**

**Table A8: Pollutants and meteorological data monitoring by the MAML.**

| Pollutant | Operating Range | |
|---|---|---|
| | Lower Detection Limit* | Upper Detection Limit** |
| Ammonia ($NH_3$) | 0.001 ppm | 5 ppm |
| Ozone ($O_3$) | 0.001 ppm | 0.5 ppm |
| Carbon Monoxide (CO) | 0.1 ppm | 50 ppm |
| **Hydrocarbons** | | |
| Methane ($CH_4$) | 0.1 ppm | 20 ppm |
| Reactive Hydrocarbons (RHC) | 0.1 ppm | 20 ppm |
| Total Hydrocarbons (THC) | 0.1 ppm | 20 ppm |
| Polycyclic Aromatic Hydrocarbons (PAH) | 3 $ng/m^3$ | 1000 $ng/m^3$ |
| **Oxides of nitrogen** | | |
| Nitrogen dioxide ($NO_2$) | 0.0006 ppm | 1 ppm |
| Nitric Oxide (NO) | 0.0006 ppm | 1 ppm |
| Oxides of nitrogen ($NO_x$) | 0.0006 ppm | 1 ppm |
| **Particulate Matter** | | |
| Total Suspended Particulates (TSP) | 1 $\mu g/m^3$ | 1.0 $g/m^3$ |
| Particulate Matter <10µm ($PM_{10}$) | 1 $\mu g/m^3$ | 1.0 $g/m^3$ |
| Particulate Matter <2.5µm ($PM_{2.5}$) | 1 $\mu g/m^3$ | 1.0 $g/m^3$ |
| **Sulphur Compounds** | | |
| Hydrogen Sulphide ($H_2S$) | 0.001 ppm | 1 ppm |
| Total Reduced Sulphur (TRS) | 0.001 ppm | 1 ppm |
| Sulphur Dioxide ($SO_2$) | 0.001 ppm | 2 ppm |
| **Meteorological data** | | |
| Wind Speed | 0 km/hr | 200 km/hr |
| Wind Direction | 0 degrees | 360 degrees |
| Temperature | -40 °C | 50 °C |
| Relative humidity | 0% | 100% |

ppm - parts per million

$ng/m^3$ = nanograms per cubic metre

$\mu g/m^3$ = micrograms per cubic metre

$g/m^3$ = grams per cubic metre

* The ***lower detection limit*** indicates the *minimum* amount of pollutant and the lower limit of meteorological data can be measured by the instrument.

** The ***upper detection limit*** indicates the *maximum* amount of pollutant the instrument can detect and the upper limit for meteorological data measured. This limit is set to provide the optimum precision over that range. The upper limit can be raised, however, precision at the lower levels (where most levels are monitored) is then compromised.

**Table A8: Pollutants and meteorological data monitoring by the MAML.**

| Pollutant | Operating Range | |
|---|---|---|
| | Lower Detection Limit* | Upper Detection Limit** |
| Ammonia **($NH_3$)** | 0.001 ppm | 5 ppm |
| Ozone **($O_3$)** | 0.001 ppm | 0.5 ppm |
| Carbon Monoxide **(CO)** | 0.1 ppm | 50 ppm |
| **Hydrocarbons** | | |
| Methane **($CH_4$)** | 0.1 ppm | 20 ppm |
| Reactive Hydrocarbons **(RHC)** | 0.1 ppm | 20 ppm |
| Total Hydrocarbons **(THC)** | 0.1 ppm | 20 ppm |
| Polycyclic Aromatic Hydrocarbons **(PAH)** | 3 $ng/m^3$ | 1000 $ng/m^3$ |
| **Oxides of nitrogen** | | |
| Nitrogen dioxide **($NO_2$)** | 0.0006 ppm | 1 ppm |
| Nitric Oxide **(NO)** | 0.0006 ppm | 1 ppm |
| Oxides of nitrogen **($NO_x$)** | 0.0006 ppm | 1 ppm |
| **Particulate Matter** | | |
| Total Suspended Particulates **(TSP)** | 1 $\mu g/m^3$ | 1.0 $g/m^3$ |
| Particulate Matter <10µm **($PM_{10}$)** | 1 $\mu g/m^3$ | 1.0 $g/m^3$ |
| Particulate Matter <2.5µm **($PM_{2.5}$)** | 1 $\mu g/m^3$ | 1.0 $g/m^3$ |
| **Sulphur Compounds** | | |
| Hydrogen Sulphide **($H_2S$)** | 0.001 ppm | 1 ppm |
| Total Reduced Sulphur **(TRS)** | 0.001 ppm | 1 ppm |
| Sulphur Dioxide **($SO_2$)** | 0.001 ppm | 2 ppm |
| **Meteorological data** | | |
| Wind Speed | 0 km/hr | 200 km/hr |
| Wind Direction | 0 degrees | 360 degrees |
| Temperature | -40 °C | 50 °C |
| Relative humidity | 0% | 100% |

ppm - parts per million

$ng/m^3$ = nanograms per cubic metre

$\mu g/m^3$ = micrograms per cubic metre

$g/m^3$ = grams per cubic metre

* The ***lower detection limit*** indicates the *minimum* amount of pollutant and the lower limit of meteorological data can be measured by the instrument.

** The ***upper detection limit*** indicates the *maximum* amount of pollutant the instrument can detect and the upper limit for meteorological data measured. This limit is set to provide the optimum precision over that range. The upper limit can be raised, however, precision at the lower levels (where most levels are monitored) is then compromised.